CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

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FORTY-SIXTH YEAR OF PUBLICATION

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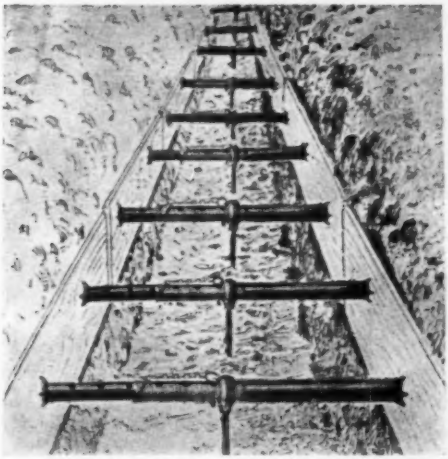

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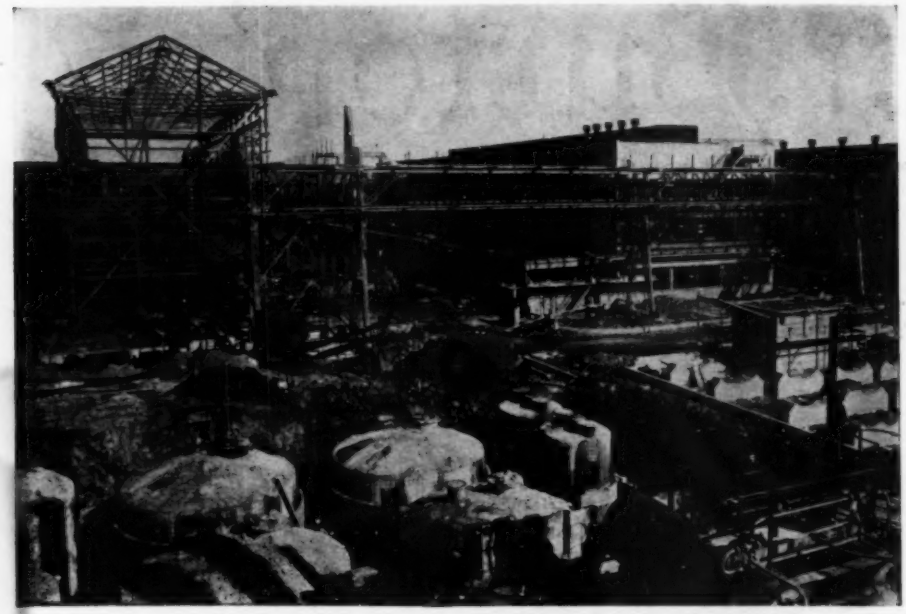

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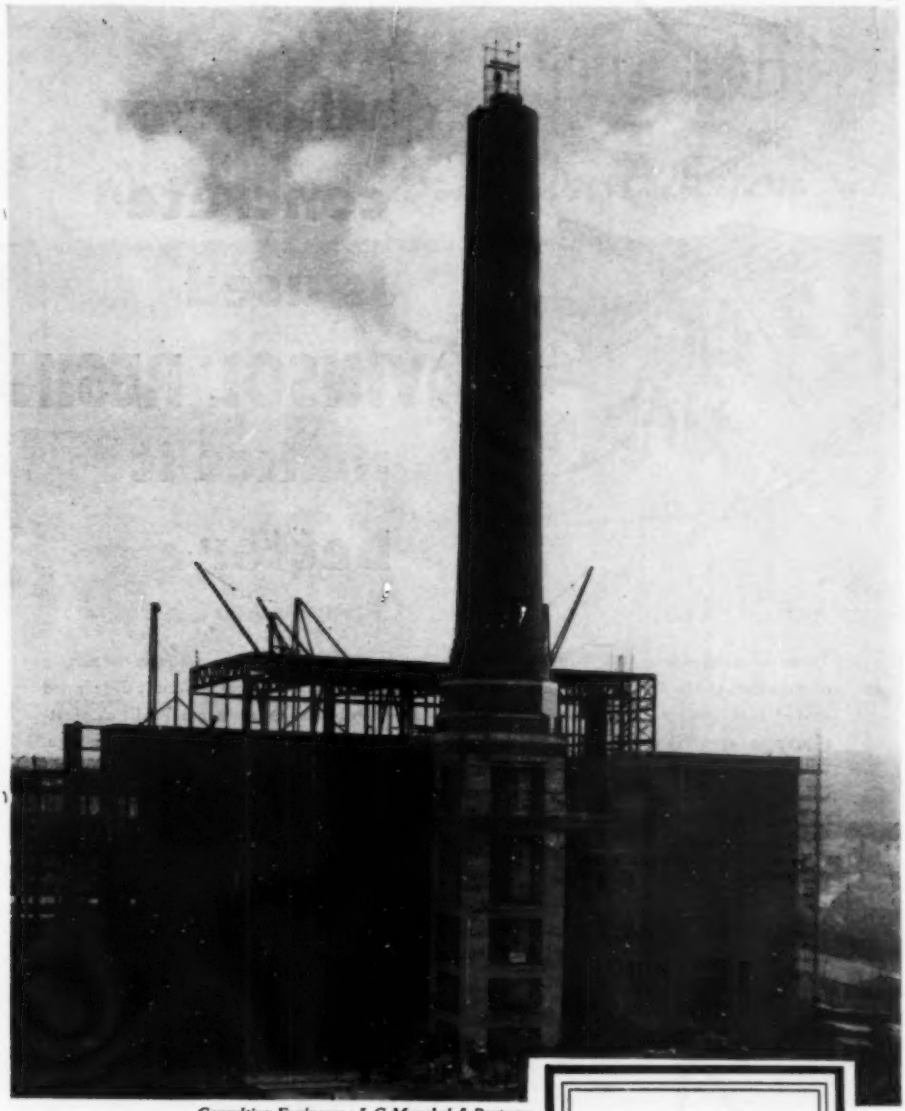

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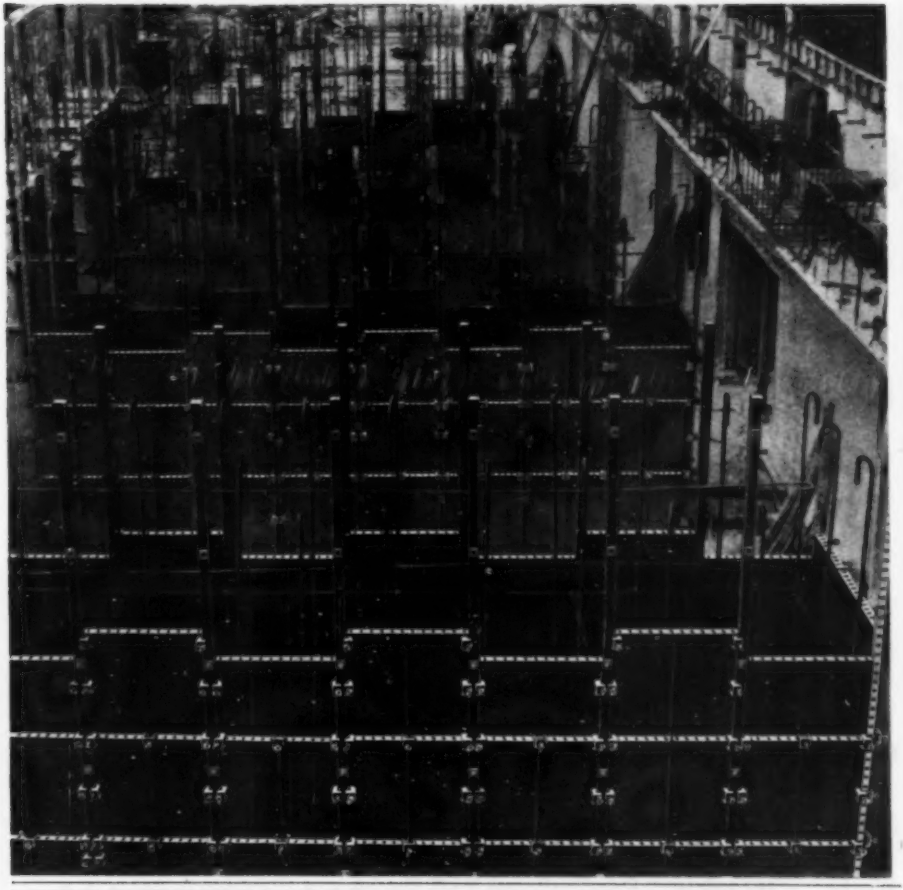

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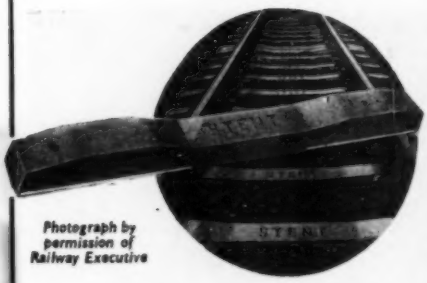

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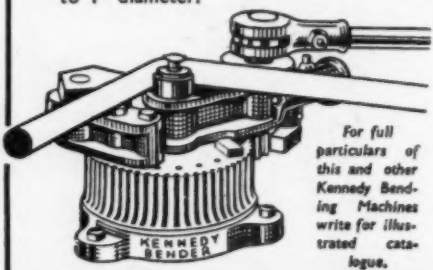

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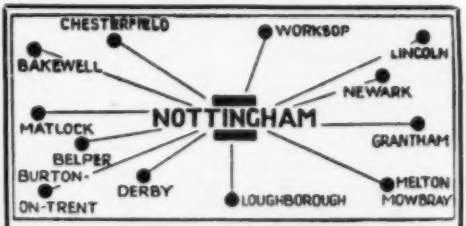

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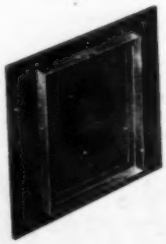

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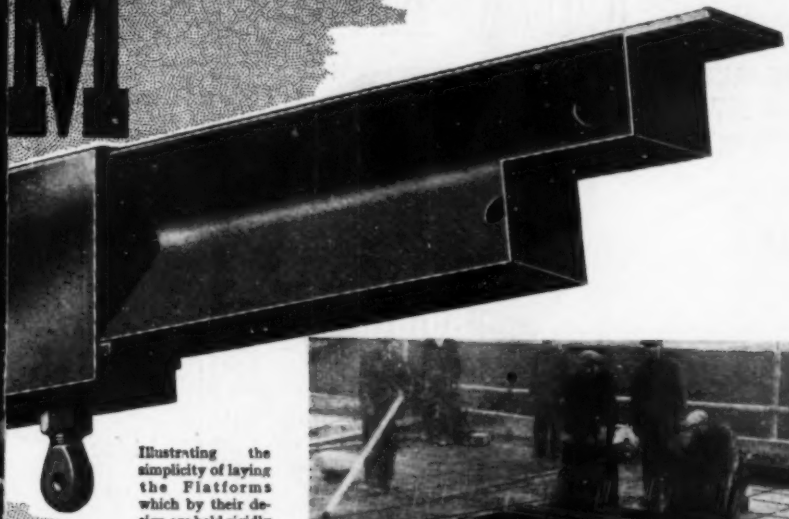

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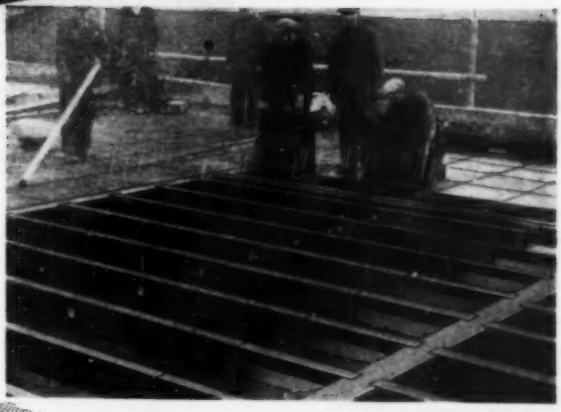

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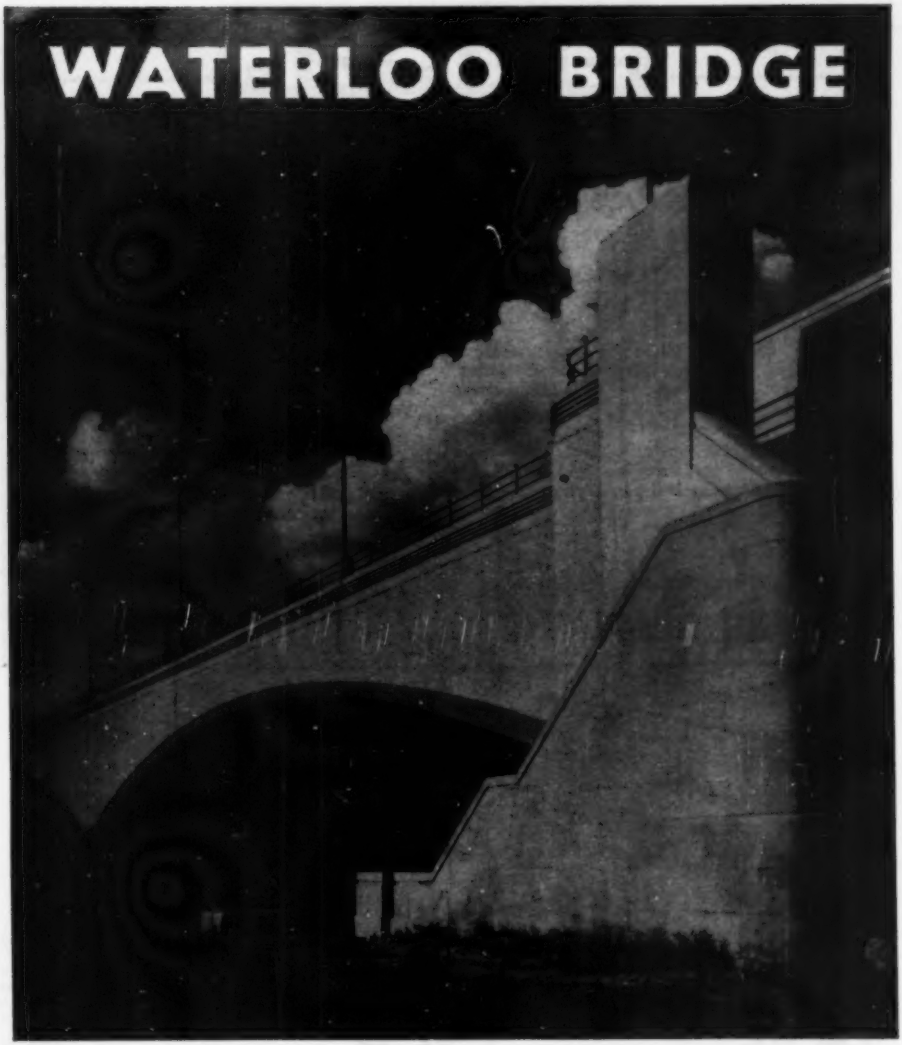

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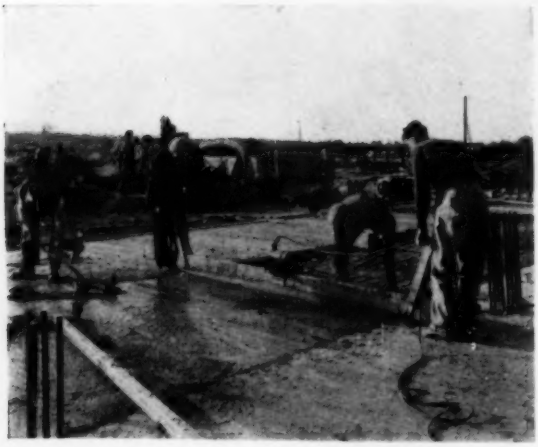

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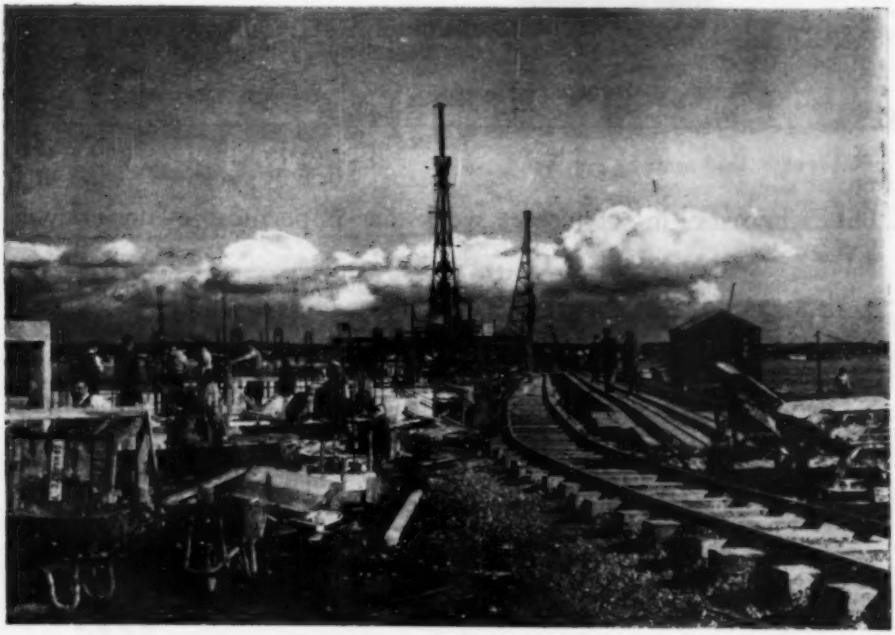

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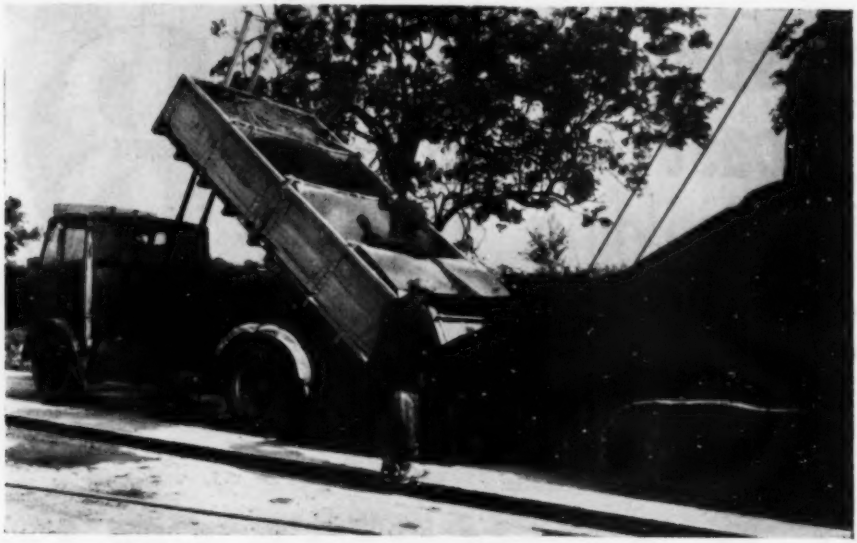

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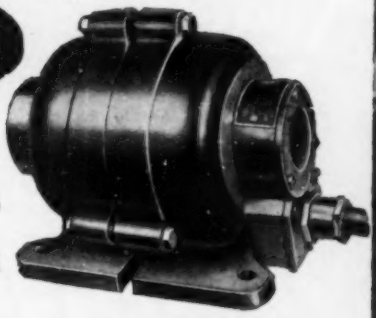

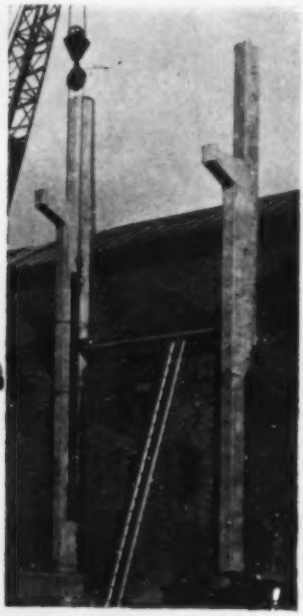

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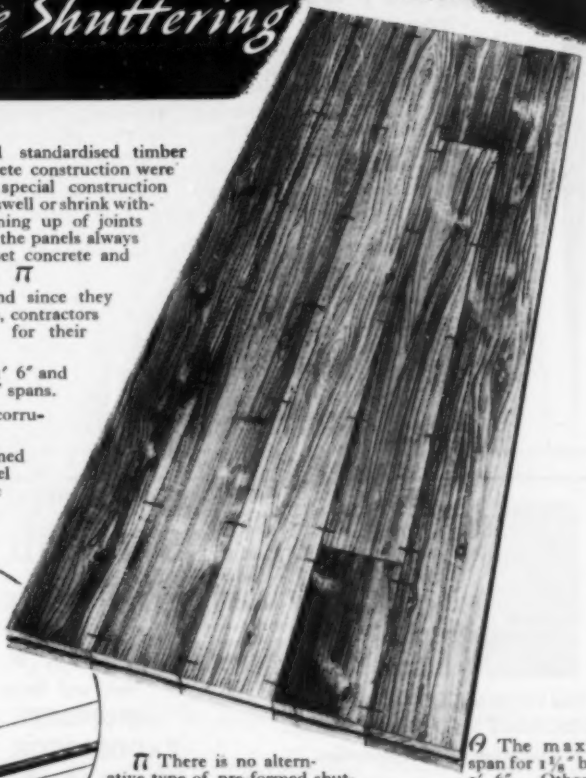

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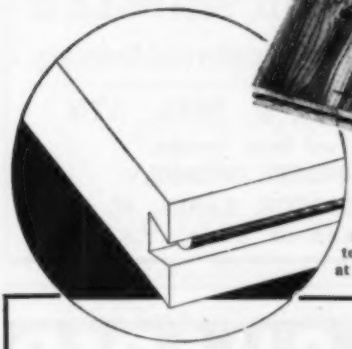

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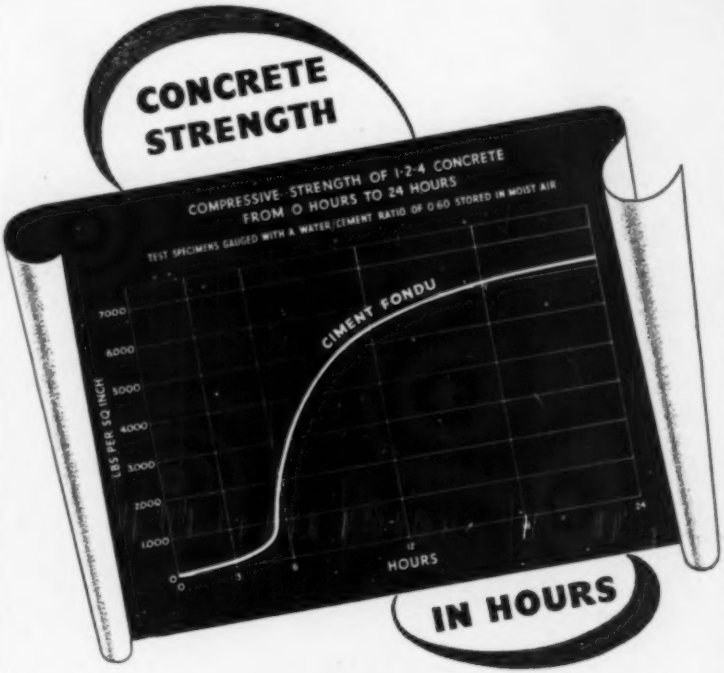

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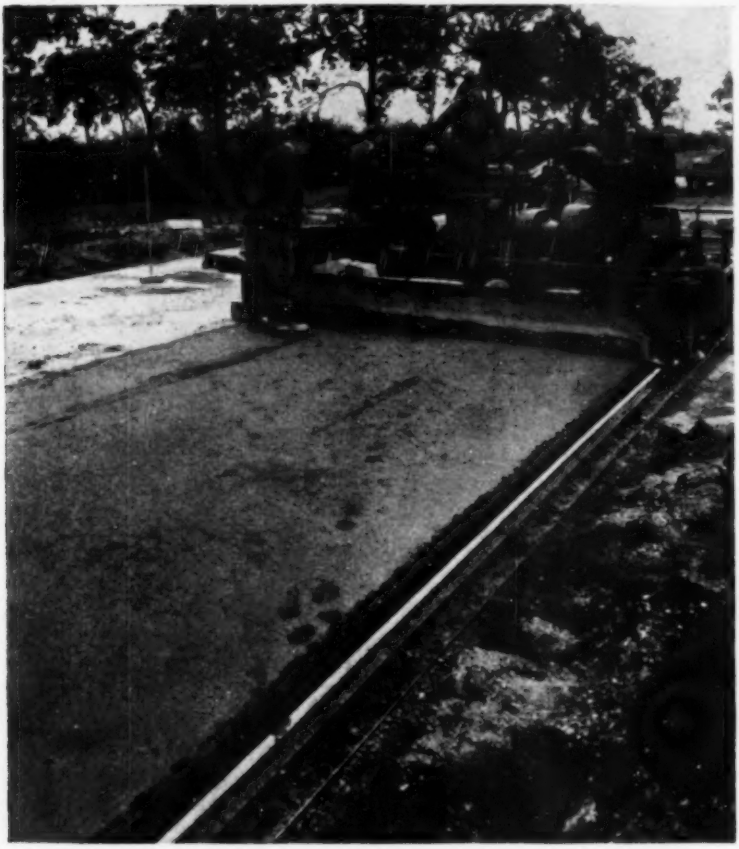

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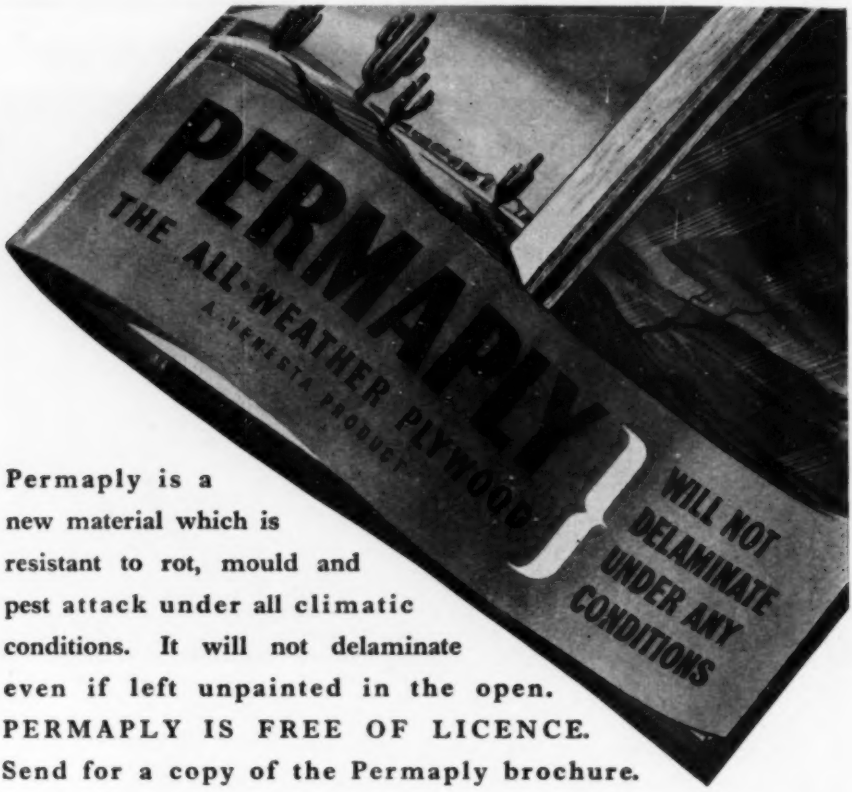

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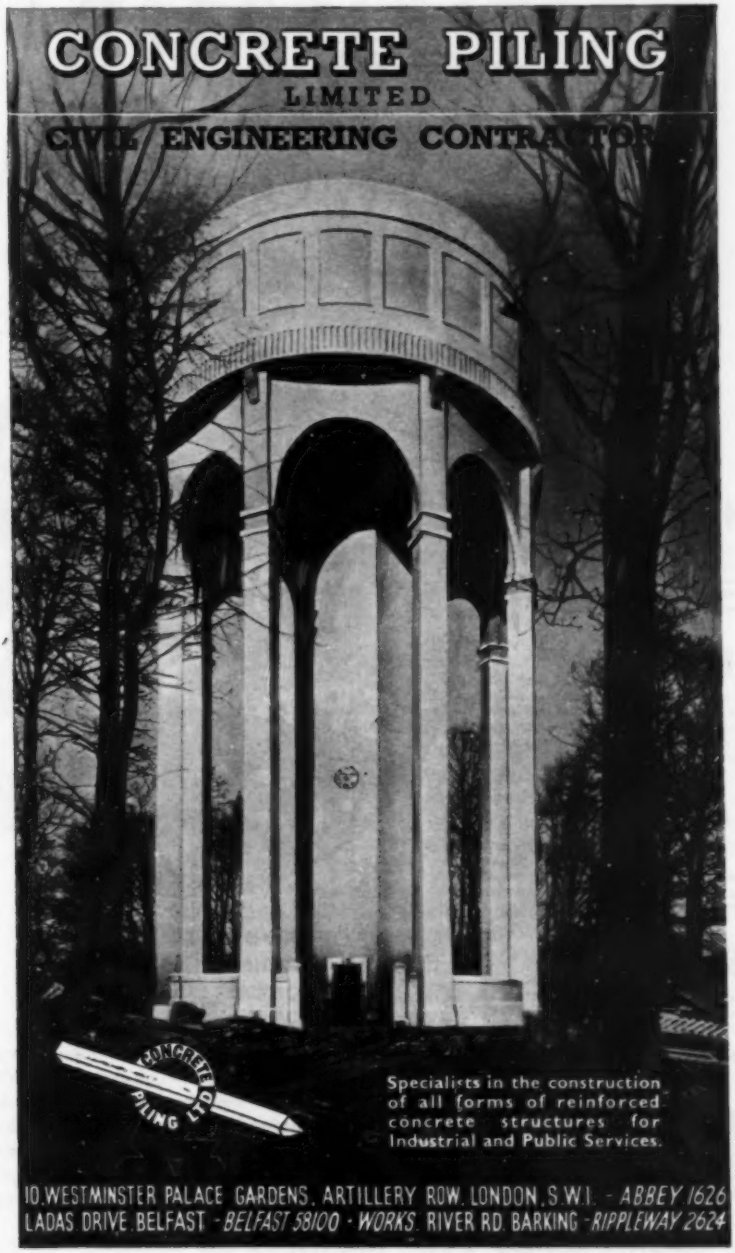
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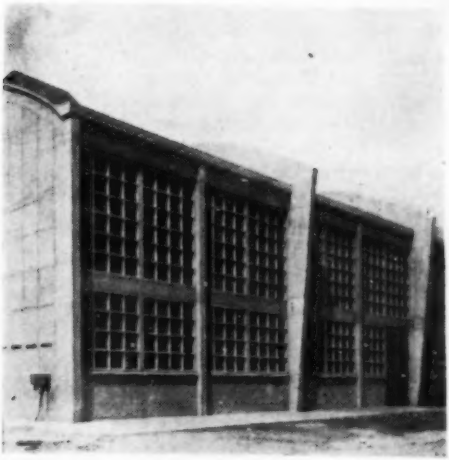

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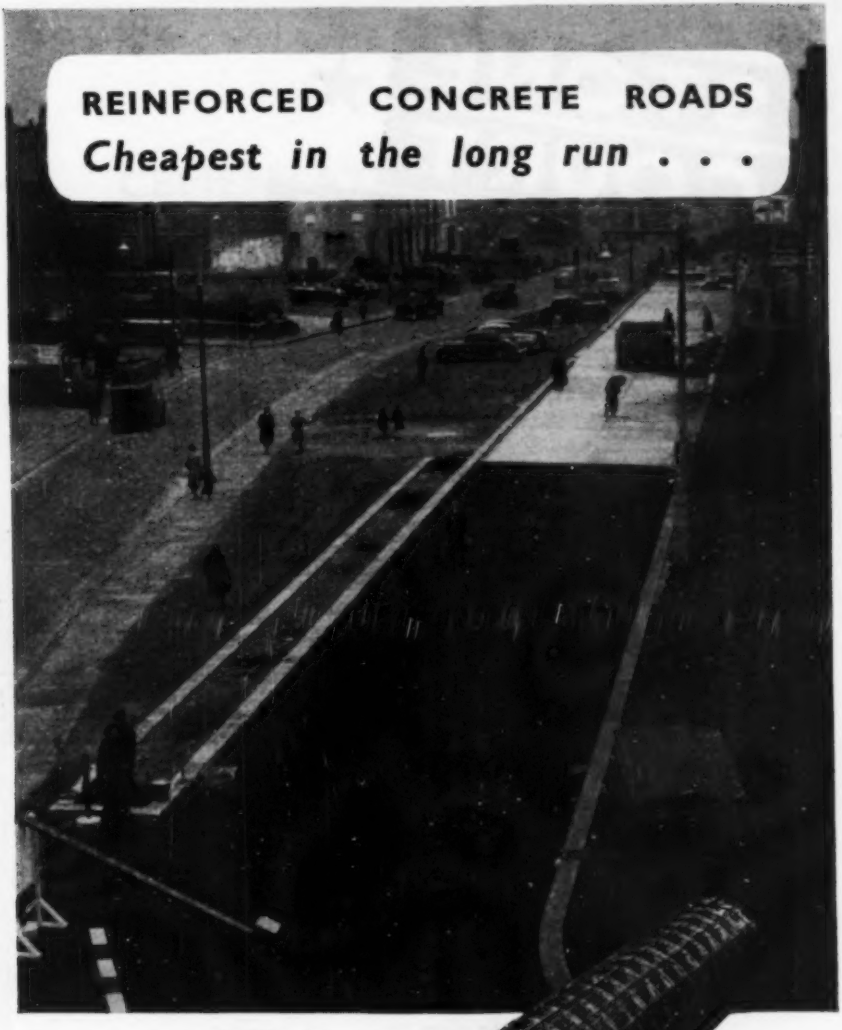

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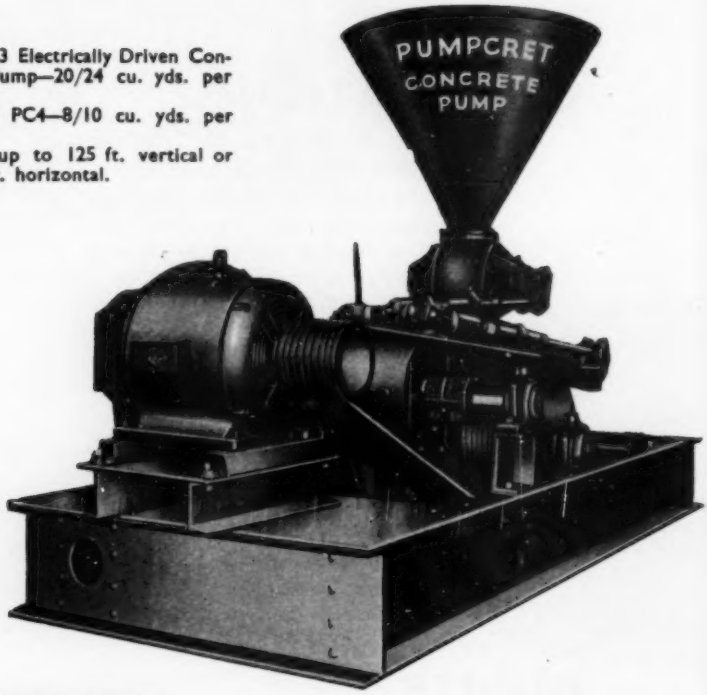

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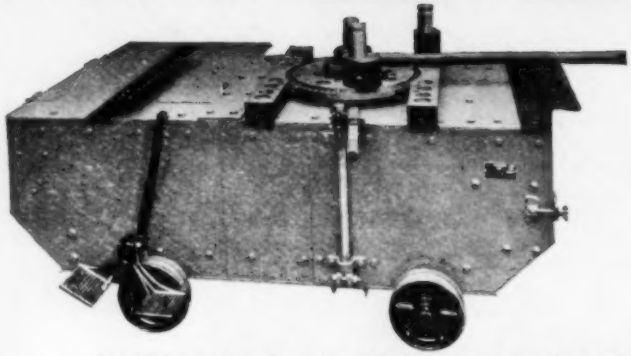

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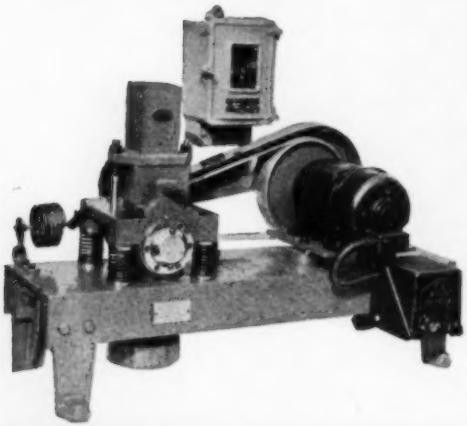

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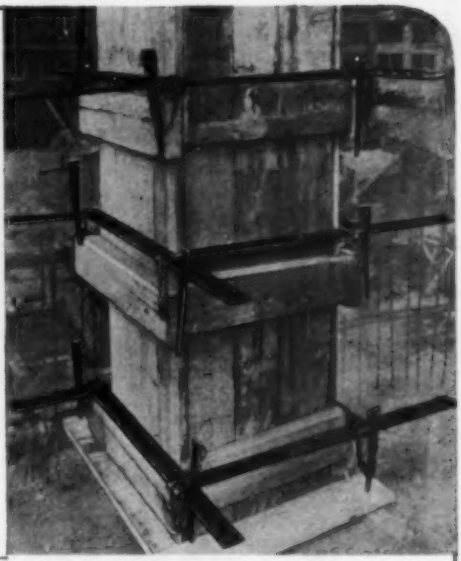

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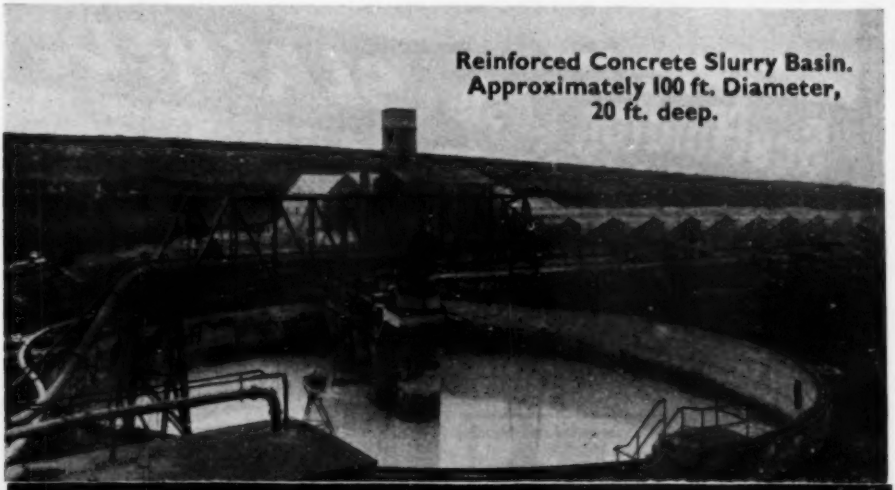

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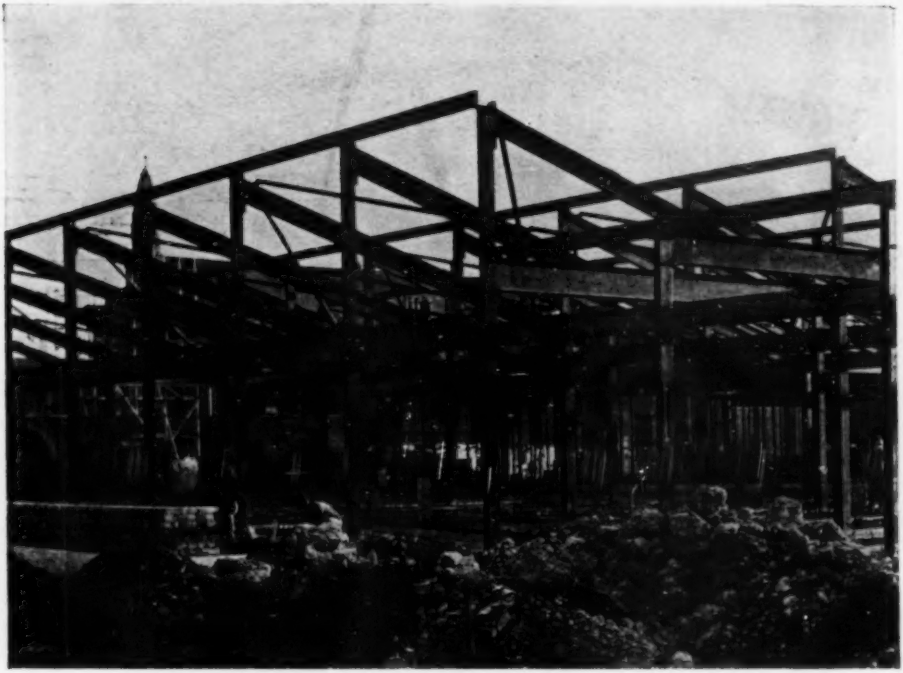

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EDITORIAL NOTES

Liquid-Containing Structures.

THE knowledge and foresight of the authors of a code of practice can be judged by the extent of the alterations that are necessary when the code is revised after it has been in use for several years. The "Code of Practice for the Design and Construction of Reinforced Concrete Structures for the Storage of Liquids", issued by the Institution of Civil Engineers, is an outstanding example of such a code for, although it was first published in the year 1938, in the new edition published recently there is hardly any alteration to the main recommendations. The alterations are mainly the replacement of some references to the D.S.I.R. Code of 1934 by similar references to the British Standard Code, CP. 114 (1948), and to British standards. The additions are in the form of two supplements, one of which deals with bituminous materials for joints (and was summarised in this journal for July, 1949), and the other relates to prestressed concrete.

In the new edition of the main code, the two principles now commonly adopted in the design of water-containing structures are retained, namely, first to take reasonable precautions to avoid cracking of the concrete, and secondly to ensure structural stability should cracking occur. The second principle no doubt ensures against local or extensive defects due to bad workmanship. Since resistance to cracking necessitates thicker reinforced concrete members than are required for resistance to bending or to bending and direct force, the compressive stress in the concrete, assuming it to be cracked, is generally much less than is permitted by the code. Concrete strong in compression is necessary, however, to ensure high tensile strength and also to reduce permeability, since the greater compressive strength is accompanied by greater density.

There is no recommendation for the tensile stress permitted in the concrete when resistance to cracking is required in members subjected to bending and tension at the same time, as is very common in rectangular tanks. If the bending moment on the member is negligible compared with the tensile force, there seems no doubt that the member should be designed as one in direct tension and the tensile stress limited to 175 lb. per square inch. Likewise, if the bending moment preponderates the member could justifiably be designed for the rules relating to a member subjected to bending only and the tensile stress limited to 250 lb. per square inch. But there are many intermediate cases. In the absence of a recommendation to the contrary, it is reasonable to suppose that a member in which

the combined stresses are entirely tensile must be designed for the stress permitted in a member subjected to direct tension, but if compressive stresses as well as tensile stresses are present the higher tensile stress might be permissible.

The direct tensile stress recommended in reinforcement is 12,000 lb. per square inch, as in the first edition, if it is assumed that the concrete is cracked. The greater width or frequency of the very fine cracks caused by slightly higher or even much higher stresses is hardly likely to be more detrimental to the water-tightness of the structure or to the protection of the reinforcement than the cracks that occur with a stress of 12,000 lb. per square inch. It may be that the low stress permitted is a survival from earlier days when, in order that the tensile stresses in the concrete should not be unreasonably great, a low tensile stress was assumed in the reinforcement of a liquid-containing structure designed without direct reference to resistance to cracking. Liquid containers designed in accordance with the more logical principles of the code are heavier and no doubt stronger in resistance to cracking than many of the structures built thirty years ago and which are still in good condition. It is not the purpose of a code of good practice to consider economy, but if the cost is taken into account the cost of the additional concrete required to resist cracking would in part be offset by reducing the amount of reinforcement required by the code when cracking is assumed to have occurred.

Ill-effects arising from a high tensile stress in round mild steel bars depend on the width of cracks, and it is conceivable that, if cracking is likely to be due to poor concrete rather than to overloading, it is equally likely that one or two wider cracks instead of a larger number of finer cracks may occur at the weak part. This likelihood is reduced if bars are used that have a greater resistance to failure of bond. Even if it is thought unwise to increase the tensile stress specified for plain round bars, there appears to be a case for permitting a higher tensile stress in deformed bars—it is noted that cold-twisted bars are now permitted.

Protection against corrosive liquids (except sea-water) is still considered to be outside the scope of this code. In view of the volume of advice, often unconfirmed and of doubtful origin, that has been published on this subject, it would be valuable if treatments which have been successful were described or recommended.

The supplement on prestressed concrete is, in our opinion, premature. Although the compression of the walls of concrete tanks was one of the earliest applications of prestressed concrete, few other than specialists in prestressed concrete have the experience, although they may have the theoretical knowledge, necessary to design and supervise the construction of prestressed concrete tanks. An hydraulic structure is unlike a building insofar that a building may never be subjected to the loads assumed in the design, whereas the calculated loads and pressures due to liquids actually occur ; there is no reserve of safety. To one who wishes to design a prestressed concrete tank, the elementary account in the code of what prestressed concrete is should be unnecessary. The exact design data, much of which has to be assumed, will no doubt meet with criticism. The necessity of the construction of a prestressed concrete tank being properly supervised is important, but the qualifications of the supervisor is not, as stated in the code, experience of reinforced concrete or prestressed concrete ; experience of prestressed concrete is of prime importance.

An Introduction to the Displacement Method of Frame Analysis.

By G. P. MANNING, M.Eng., M.Inst.C.E.

THE fundamental conceptions of the displacement method of frame analysis are: (1) The idea that the simplest state of a structural member is when it has no bending moment at its ends (that is when it is "simply supported") is abandoned, and replaced by the idea that the simplest state of a structural member is when there is no movement at its ends. (2) After writing down the primary "no-movement" bending moments and shearing forces, the equilibrium and deflections of the members themselves are forgotten. The equilibrium of the joints only is considered. (3) The idea that the load causes deflections of the

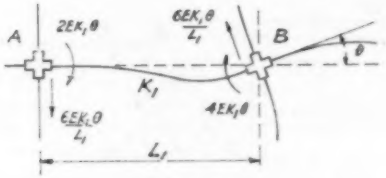


Fig. 1.

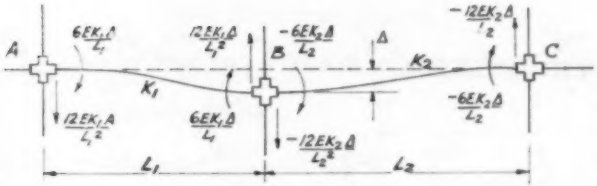


Fig. 2.

frame is abandoned. It is assumed that each joint of the frame deliberately twists and sways, thus causing additional bending moments and shearing forces on itself and on other joints. (4) All Cartesian ideas of positive and negative quantities are replaced by the convention that bending moments and shearing forces that tend to rotate a joint clockwise are positive. By drawing all rotations at the joints anticlockwise, all bending moments and shearing forces caused on all joints by these rotations are positive.

Fixed-ended Frames of Members of Constant Section.

The displacement method was first evolved for dealing with members whose cross section varies (such as a beam with a parabolic soffit). The only variation introduced by such members, or by a frame which is pin-jointed at its supports, is the substitution of one set of numerical coefficients for another. The only coefficients required for the analysis of fixed-ended frames of members of constant section are shown in *Figs.* 1 and 2. *Fig.* 1 shows the additional bending moments and shearing forces imposed by member AB on joints A and B when

joint B twists through an angle θ. *Fig.* 2 shows the additional bending moments and shearing forces imposed on joints A, B, and C when joint B sinks through a distance Δ.

Aids to Analysis.

Draw all joints as small solid blocks and draw all members as single lines. Tabulate the effects of the movements of the joints; this makes it much easier to check the analysis. Draw all joint rotations anticlockwise; this is important, as it makes all the effects positive and eliminates all chance of a wrong sign at this stage. It is generally easier to draw side sway from left to right, but this is not so important, as the signs of the bending moments and shearing forces caused by side sway are obvious. Remember that twisting any joint causes bending moments and shearing forces at both ends of all members connected

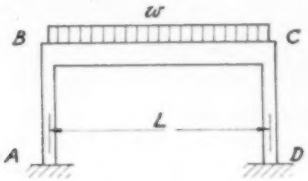


Fig. 3.

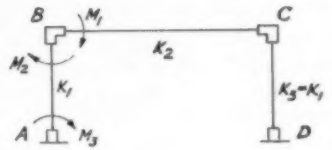


Fig. 4.

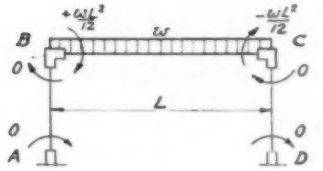


Fig. 5.

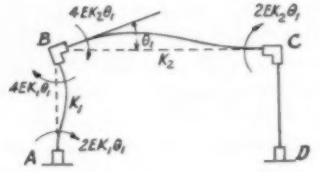


Fig. 6.

at that joint. The values of the shearing forces are only needed if the frame has side sway, settlement, shrinkage, or other causes which displace the joints horizontally or vertically.

Simple Example.

Fig. 3 shows a symmetrical rectangular frame ABCD fixed at supports A and D and composed of three members each of constant section and carrying a distributed load w on the member BC. The stiffness coefficients $\frac{I}{L}$ are K_1, K_2, and K_3, and $K_3 = K_1$. As the frame and the load are both symmetrical, there will be no side sway. Draw the frame in line diagram as in *Fig.* 4. Bending moment M_1 is the clockwise moment imposed on joint B by member BC, while M_2 and M_3 are the clockwise moments imposed on joints B and A by member AB. As there is no side sway we need not consider the shearing forces. Draw the primary loading as in *Fig.* 5. Under this loading of the frame all the joints are held in their unloaded positions, and the clockwise bending moments

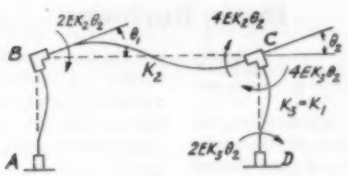


Fig. 7.

exerted by the members on the joints are as shown in *Fig.* 5. Now rotate joint B into its final position. This action causes additional bending moments as shown in *Fig.* 6. Then rotate joint C into its final position, causing further bending moments as in *Fig.* 7. Tabulate these effects as follows:

	M_1	M_2	M_3
No movement (*Fig.* 5) .	$+\frac{wL^2}{12}$	0	0
Due to θ_1 (*Fig.* 6) . .	$4EK_2\theta_1$	$4EK_1\theta_1$	$2EK_1\theta_1$
Due to θ_2 (*Fig.* 7) . .	$2EK_2\theta_2$	0	0

Since the whole frame has now moved into its final position, joint B must now be in equilibrium, that is,

$$\text{Final } M_1 + \text{final } M_2 = 0.$$

Therefore, $$+\frac{wL^2}{12} + 4EK_2\theta_1 + 2EK_2\theta_2 + 4EK_1\theta_1 = 0,$$

and, as $\theta_2 = -\theta_1$, by symmetry

$$E\theta_1(4K_1 + 2K_2) = -\frac{wL^2}{12} \text{ and } E\theta_1 = -\frac{wL^2}{12}\cdot\frac{1}{(4K_1 + 2K_2)}.$$

Also, $$\text{Final } M_1 = +\frac{wL^2}{12} + 4EK_2\theta_1 + 2EK_2\theta_2 = +\frac{wL^2}{12} + 2EK_2\theta_1$$

$$= \frac{wL^2}{12}\cdot\frac{4K_1}{(4K_1 + 2K_2)}.$$

$$\text{Final } M_2 = 4EK_1\theta_1 = -\frac{wL^2}{12}\cdot\frac{4K_1}{(4K_1 + 2K_2)} = -M_1.$$

$$\text{Final } M_3 = 2EK_1\theta_1 = -\frac{wL^2}{12}\cdot\frac{2K_1}{(4K_1 + 2K_2)}.$$

In practice only one line diagram would be required for this type of frame instead of the four diagrams in *Figs.* 4 to 7.

It should be noted that the value of $E\theta_1$ is negative, showing that joint B actually rotates clockwise and not anticlockwise as assumed. Also note that M_1 is positive while M_2 and M_3 are negative. M_1 causes tension on the top of the beam, M_2 causes tension on the outside of the column, and M_3 causes tension on the inside of the column.

Book Reviews.

"Prestressed Concrete." By Professor G. Magnel. Second Edition. (London: Concrete Publications, Ltd. 1950. Price 15*s*. 3·50 dollars in Canada and U.S.A.)

ONLY two years after the publication of the first edition, a new edition of this well-known book on the theory and practice of prestressed concrete structures has become necessary. The second edition has 80 more pages and 100 more illustrations than the first, principally due to the inclusion of designs and illustrations of more structures, some of which are in Great Britain, including framed structures, continuous-beam bridges, and tanks. The chapter on precast prestressed concrete products has been rewritten and much enlarged to include detailed descriptions and illustrations of the latest methods of manufacture.

Although the fundamental theory, which is simply described, and the practical general semi-graphical methods of design recommended by the author are unaltered, there is an improved method for the calculation of the stresses in the ends of beams, and the author apparently no longer considers that haunches are undesirable at the supports of continuous beams of equal spans. The theoretical discussions are throughout supported by tests made in the author's laboratory or on the site and include, among many others, a test to destruction of a bridge girder of 155 ft. span, and tests on the ends of beams and on the buckling of prestressed concrete rings. The results of the tests establish that the factors of safety of structures designed by the author's methods are sufficient; no theory of the ultimate resistance of a prestressed concrete beam is given.

"Hormigon Vibrado." By G. Barceló. (Madrid: Editorial Dossat, S.A. 1950.)

THIS book of about 250 pages, in the Spanish language, collates data and opinions on the use of mechanical vibration to compact concrete. Most of the matter is in praise of vibration, but some descriptions of the right and wrong methods are included. It is stated that it is possible to reduce the factor of safety in the design calculations of structures constructed with vibrated concrete because of the greater uniformity of the material—many engineers may question this. The properties of concrete and the effect of vibration are dealt with at length and the attempts to devise a theory of vibration (as applied to wet concrete) are described. The vibrators described are mainly of continental design. The practical parts of the book are well illustrated and the chapter on shuttering is useful. A small chart showing costs (in Spain) of various types of roads states that a vibrated concrete slab, although not cheaper than cement-grouted macadam, is cheaper than asphalt on concrete, and much less costly than granite sets on concrete.

A Code for Durability of Buildings.

A NEW code (British Standard Code of Practice, CP.3, Chapter IX (1950): "Durability" price 4*s*. from the British Standards Institution) deals in three pages in a general manner with the principles underlying considerations of the durability of buildings. Buildings are classified with regard to the required life of the structural parts, which may be 100 years, 40 years, 10 years, or less than 10 years. The non-structural parts, such as partitions, roof coverings, and finishes may have a life of from 5 years to 100 years. In appendixes there are detailed considerations of the causes of, and the susceptibility of building materials to, deterioration, and the effects of ground waters on cast-in-situ and precast concrete. When the concentration of sulphur trioxide exceeds 1 part in 1000 parts of ground water or more than $\frac{1}{2}$ per cent. in clay the use of high-alumina and supersulphate cements is recommended for cast-in-situ concrete. It is stated that 1 : 2 : 4 concrete does not generally require special measures if the concentration is less than 0·3 part in 1000 parts of ground water or less than 0·2 per cent. in clay, except that if concrete is exposed to water pressure from one side only the mixture recommended is 1 : $1\frac{1}{2}$: 3. Between these limits, dense ordinary 1 : $1\frac{1}{2}$: 3 concrete in clay may not suffer, but resistant cements are advisable, as they are also if concrete is subjected to water pressure from one side only.

The Glen Affric Hydro-Electric Works.—II.*

THE TUNNELS.

THE Mullardoch–Benevean tunnel is 5738 yd. long, in which distance it falls 3 ft. It is of horse-shoe cross section (*Fig.* 12) of 15 ft. 9 in. equivalent diameter, and is unlined except for the invert which is of concrete of quality A (as described for the dams in the previous article). The maximum hydrostatic pressure is 32 lb. per square inch.

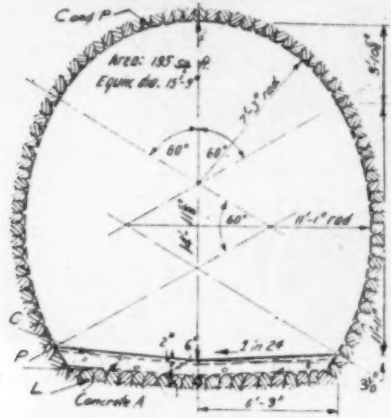


Fig. 12.—Mullardoch–Benevean Tunnel: Cross Section.

The Benevean–Fasnakyle tunnel (*Fig.* 13) is 5788 yd. long and is in three sections, namely, an upper low-pressure tunnel 4113 yd. long, a lower high-pressure tunnel 1408 yd. long, and three parallel pipe-tunnels each 267 yd. long. The low-pressure and high-pressure tunnels are lined with concrete of quality A. The low-pressure tunnel is of horse-shoe cross section of 14 ft. 6 in. equivalent diameter, and the circular high-pressure tunnel is 14 ft. 6 in. diameter. Each of the three pipe-tunnels contains a steel pipe of 8 ft. 4 in. diameter backed with concrete. The maximum water pressures are 62 lb. per square inch in the low-pressure tunnel and 260 lb. per square inch in the high-pressure tunnel. At the junction of the low-pressure and high-pressure tunnels there is a surge shaft 150 ft. deep and 45 ft. diameter, which is continued downwards 341 ft. as a vertical shaft to connect the two tunnels.

Intake.

At the inlet to the low-pressure section of the Benevean–Fasnakyle tunnel there is a reinforced concrete intake structure (*Fig.* 14), which, excluding the gate-house, is 86 ft. high. The lower part of the structure, which is 29 ft. 6 in. wide

*Concluded from February, 1951.

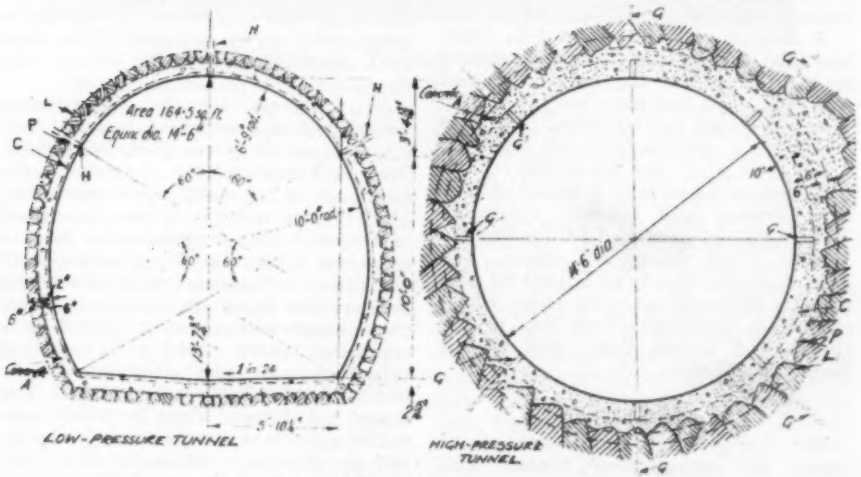


Fig. 13.—Benevean–Fasnakyle Tunnel: Cross Sections.

and will be submerged when the reservoir is full, contains an emergency gate, a control gate, an 80-ft. by 21-ft. coarse screen, and a 75-ft. by 20-ft. fine screen. The gate-house surmounting the intake structure is 54 ft. long, 23 ft. wide, and 32 ft. high, and access is by means of a reinforced concrete bridge of two spans each 26 ft. 8 in. long. The volumetric proportions of the reinforced concrete are 1 : 4.

Boring.

The rock in which the tunnels are driven is hard mica schist varying from pelitic to psammitic schist, and containing strata of pegmatite. The Mullardoch–Benevean tunnel was driven from both ends, but two adits were formed in the line of the low-pressure section of the Benevean–Fasnakyle tunnel. The net quantities of rock to be excavated were 134,000 cu. yd. in the Mullardoch–Benevean tunnel, and 169,000 cu. yd. in the low-pressure and high-pressure tunnels, pipe-tunnels, surge-shaft, and shaft to the high-pressure tunnel. The actual amount of rock excavated exceeded these quantities which are based on excavation to the contract payment-line only. The limit, payment, and clearance lines are indicated by L, P, and C respectively in *Figs.* 12 and 13. Where breaks of rock occur outside the limit line the space was filled with lean concrete or with rough masonry in cement mortar before lining of the tunnel commenced.

A drilling carriage on an 8-ft. track was used. The depth of the holes drilled in the face of the high-pressure tunnel was 10 ft. 6 in., and there were generally about 53 holes in each face. The face advanced in each shift of 10½ hours by about 9 ft. 6 in., and about 160 cu. yd. of broken rock had to be disposed of after each drilling and blasting operation. Rocker-shovels were used for loading the wagons, which ran on 2-ft. track. The spoil from the Benevean–Fasnakyle tunnel was deposited on a tip about half a mile from the downstream end of the tunnel and in the flood area of the Benevean reservoir.

Lining.

The low-pressure tunnel was lined before the high-pressure tunnel. The procedure in the low-pressure tunnel was

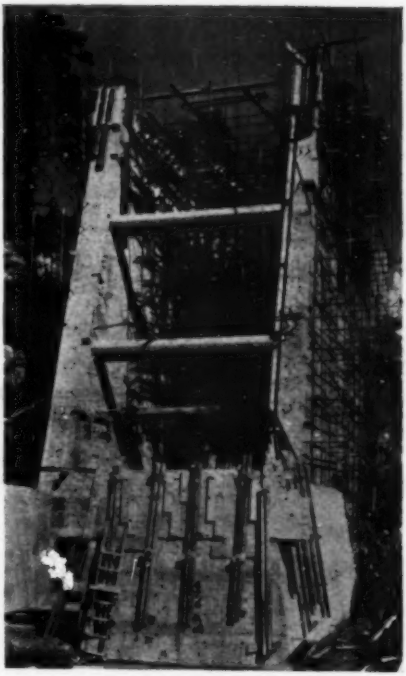


Fig. 14.—Benevean–Fasnakyle Tunnel : Intake.

to line the roof and sides first and then to concrete the invert. The concrete materials were batched at an aggregate-preparation depot, transported in skips to a mobile mixer in the tunnel, and deposited by a pneumatic placer.

The concrete for the high-pressure tunnel and pipe-tunnels was mixed outside the tunnel in two ¾-cu. yd. mixers. The proportions of the concrete in the lining are 1 : 4, using 1½-in. aggregate. The concrete was taken into the tunnel in wagons. The procedure was first to construct a benching along each side of the tunnel. The concrete in the invert between the benchings was then placed, the concave surface being formed by a segmental timber screed 5 ft. long and extending to the sides of the invert where it was supported on the benchings. The screed was dragged along by a rope, one end of which was attached to a dead-man and the other to a winch on the screed. A steel shutter, 60 ft. long and shaped to

the circular profile of the walls and roof, was brought into position and concrete was placed by hand in the walls. The concrete in the roof was placed by a pneumatic placer on a travelling gantry on to which the wagons of concrete were pulled up a ramp by a winch. The skips discharged into a tilting chute feeding the pneumatic placer. The placer (*Fig.* 15), which is of American manufacture, comprises a welded steel tank of 1 cu. yd. capacity fitted with an air-tight sliding lid. After the concrete had been placed in the tank and the lid closed, compressed air at 100 lb. per square inch was injected into the tank and forced the concrete along a 6-in. pipe that rose from the tank to the roof of the tunnel and deposited the concrete over the shuttering. The placing of concrete by hand in the walls of 60 ft. of tunnel took about 6½ hours and the same time was taken to place the concrete in the roof by the pneumatic placer. By either method about 16 cu. yd. of concrete could be placed in an hour. There are about 4 cu. yd. of concrete per foot of tunnel. Generally the distance from the finished surface of the lining to a projecting point of the surrounding rock is not less than 2 in., and not less than 5 in. to flat faces of rock. To accommodate the pipe from the pneumatic placer it was necessary to have a greater clearance, and in the high-pressure tunnel there is about 10 in. between the face of the lining and the rock. When a 60-ft. length of tunnel had been concreted, the entire plant (that is shutter, placer, and gantry) was moved along to the next position.

In the low-pressure tunnel the shutter, which was shaped to the horse-shoe profile of this tunnel, enabled 85 ft. of tunnel to be lined in one operation. At the bend in the low-pressure tunnel (*Fig.* 16), and at the transition section at the trifurcation where the high-pressure tunnel joins the three pipe-tunnels, hardboard shuttering on timber ribs was used. In these cases the lining of the straight lengths was completed before the lining at the bends.

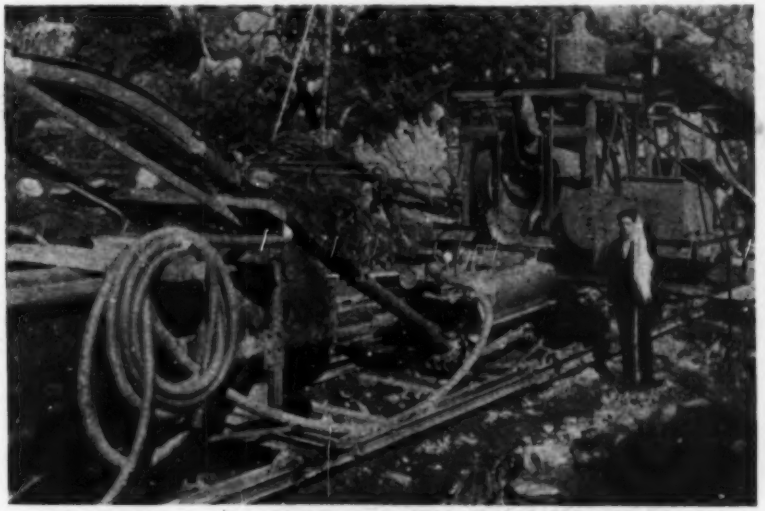


Fig. 15.—Machine for Placing Concrete Tunnel Linings.

When the linings were complete, the rock behind the lining was grouted. The primary grouting of the high-pressure tunnel was done through holes 10 ft. deep at a pressure of 100 lb. per square inch, and the secondary grouting through holes 14 ft. deep at a pressure of 300 lb. per square inch. The grout was injected through a 2½-in. steel pipe 12 in. long cast in the lining and continued as a 1½-in. hole in the rock. Eight holes (G) were provided in a ring as shown in *Fig.* 13, the rings being at

6 ft. centres along the length of the tunnel.

In the low-pressure tunnel no grout was injected through the walls or invert but in the roof there were three 1½-in. holes (H) (*Fig.* 13) at 6 ft. centres staggered, that is the distance between adjacent holes in one line was 18 ft. These holes were used for filling any voids between the concrete lining and the rock at the roof and for grouting unsound rock.

The 1 : 5 concrete surrounding each of the steel pipes in the three pipe-tunnels contains ¾-in. aggregate and was pumped from the mixers to the point of deposit. The greatest pumping distance was about 400 ft., since the pump was placed first at the trifurcation and later near the entrance to the pipe-tunnels. The concrete was deposited in layers, the 4-in. pipe being withdrawn as the top layer was placed.

Fasnakyle Generating Station.

The generating station (*Fig.* 17) on the north bank of the river Glass at Fasnakyle will contain three 22,000-kw. generators, and is 232 ft. long, 68 ft. wide, and 54 ft. high. It is a steel-framed structure with walls comprising 7½ in. of cast-in-situ reinforced concrete, 18 in. of masonry, and 1½-in. wood-wool slabs. The wood-wool slabs were used as permanent shuttering on the inner face of the concrete, the outside face being shuttered with panels of timber stiffened with steel channels. The masonry is to be applied later. The volumetric proportions of the concrete are 1 : 4, the materials being ordinary Portland cement, river sand

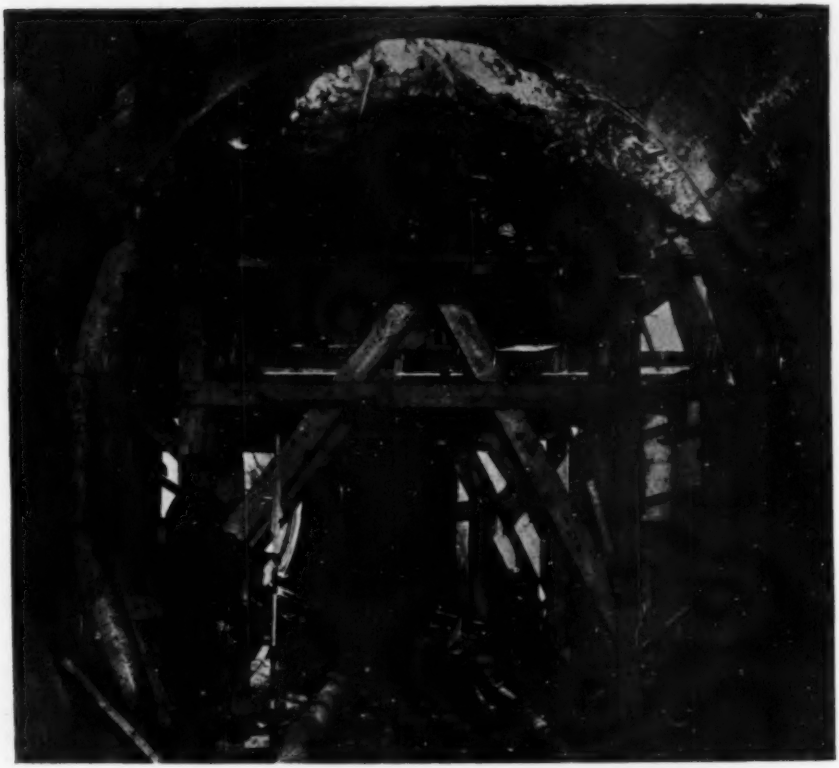


Fig. 16.—Benevean-Fasnakyle Tunnel : Shuttering at Bend.

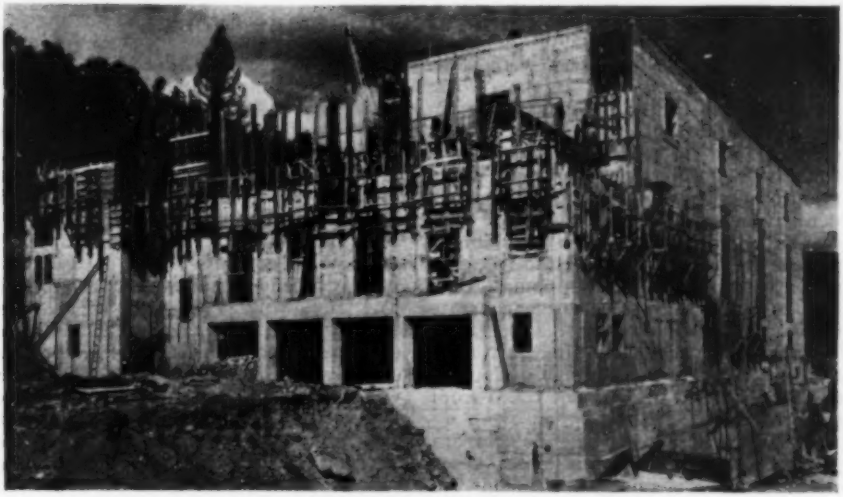


Fig. 17.—Fasnakyle Generating Station.

from ⅛-in. down, and ¾-in. to ⅛-in. crushed gravel. The concrete, of which there is about 9000 cu. yd., was placed by a 4-in. pump fed from a ½-cu.-yd. mixer, the greatest height to which the concrete was pumped being 67 ft. The large annular concrete plinths under the turbines were cast within timber shutters, and are insulated from the main structure by a layer of bituminous material. The foundation is rock of which a net quantity of 10,000 cu. yd. was excavated.

Training Courses in Concrete.

THE five-day courses of instruction in making concrete, prestressed concrete, and concrete roads, instituted by the Cement and Concrete Association last year, are to be continued from April to December, 1951. The courses are held at the Association's Training Centre at Wexham Place, Fulmer, Bucks., and particulars and application forms are obtainable from the Association at 52 Grosvenor Gardens, London, S.W.1.

Joint Engineering Conference in London.

A JOINT Engineering Conference is to be held in London at the Institution of Civil Engineers, the Institution of Mechanical Engineers, and the Institution of Electrical Engineers from June 4 to June 15. Its object is to record the contributions to the advance of civilisation by the engineers and scientists of this country during the past hundred years. In addition to the technical sessions, there will be visits to works and other places of interest and some social functions. Particulars can be obtained from the Secretariat of the Joint Engineering Conference, Institution of Civil Engineers, Great George Street, London, S.W.1.

Expanding Cement.

WE are informed by Monsieur Henry Lossier that he wishes to operate in Great Britain his British patent No. 647,581 relating to expanding cement, which was described in this journal for January, 1947. M. Lossier's address is 8 rue du Square Carpeaux, Paris 18e.

Bridge in Egypt.

TENDERS are invited by the Egyptian Ministry of Public Works for the construction of a reinforced concrete bridge over the Ibrahimia canal at Markaz Dairut, Assiut Province. The closing date for tenders is May 3, 1951. The specification will be sent on loan by the Board of Trade, Thames House North (Room 1118), Millbank, London, S.W.1 (reference C.R.E., IB, 53733/51).

Defective Concrete in Marine Works.

A REPORT published recently by the Portuguese Ministry of Public Works describes the results of an investigation of the condition of cement mortars and concretes at the principal ports in Portugal. In the north of Portugal, where granite aggregate is used, there is much defective concrete, while elsewhere concrete about fifty years old is in an almost perfect condition. The granite is generally a coarse-grain material composed of two types of mica. Defective concrete is cracked and is easily disintegrated. The following conclusions are drawn from analyses and tests of the materials used in the works and of samples taken from the structures.

The hypothesis that the defects are primarily due to the action of sea-water on the cement is rejected, although the presence of sea-water may accelerate disintegration due initially to other causes. Generally, the cements used in defective works built in the past twenty years are the same as those used in works showing no deterioration and built in the same period. The chemical composition and physical properties of the various cements are very similar and fluctuate little. It cannot be said that the concretes are deficient in cement. The quantity of cement in 1 cu. yd. of concrete showing the worst defects is from 500 lb. to 760 lb.

As the defective concrete is almost entirely confined to the area where granite occurs, it is thought that the primary cause is the interaction of the cement and aggregates. Chemical analysis of a white paste exuded from some concrete blocks weighing 90 tons suggests that reaction between the aggregate and the alkalis in the cement was occurring because the silica-content of the paste was low. The view that cement-aggregate reaction is the primary cause is strengthened by the condition of the fractures of some broken blocks, the surfaces of which were in good condition. The good condition of some concrete in the granite region is attributed to the great care taken to obtain compact concrete, thereby confirming the common view that concrete in sea-water must be well made and dense. Although the primary cause of the defects may be cement-aggregate reaction, it is apparent that the defects are strongly influenced by the sea-water.

Compression tests confirm the observations, since the strength of the cubes of defective concrete decreases in course of time, whereas the strengths of the corresponding sound concretes increase. This shows that knowledge of the early strength of concrete is not a proof that it will continue to have the same strength. The following are the compressive strengths (in lb. per square inch) of the concrete of some works that have become defective. The strength of a concrete with 500 lb. of cement per cubic yard increased from 2503 lb. at seven days to 4295 lb. at 28 days, but at three months it was 3741 lb. The strength of similar concrete at another port showed little change between seven days and one year. The strength of concrete with 600 lb. of cement per cubic yard was the same at one year as at seven days, although at three months the strength exceeded by 40 per cent. the strength at seven days. A decrease in strength after three months was common to all the defective concretes, although sound concretes with the same cement content increased in strength up to two years and in some cases up to five years and ten years.

Bursaries in Concrete Technology.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

DEPARTMENT OF CIVIL ENGINEERING

BURSARIES IN CONCRETE TECHNOLOGY

NOTICE IS HEREBY GIVEN

that the election to Bursaries in Concrete Technology tenable as from October 1951, will take place in June 1951.

Bursaries are of the value of £300 per annum, out of which the College Tuition Fee has to be paid. Under certain circumstances, the amount will be increased with industrial experience (subject to the agreement of the donors).

The course will be postgraduate, and Bursars who successfully complete the course will be eligible for the award of the Diploma of the Imperial College (D.I.C.).

Applications must be received on or before 1st June, 1951, by the Deputy Registrar, City and Guilds College, Exhibition Road, London, S.W.7, who will on written request send full information and application forms.

Fixed-Moment Fixed-Point Method of Solving Continuous Beams.

By L. S. WATTS, A.M.I.Struct.E.

THE choice of method for calculating the bending moments at the supports in continuous beams depends on the problem and on personal preference. The method described in this article is a practical one that considers bending moments from the beginning of the calculations.

Fig. 1 represents a beam continuous over three spans with varying moments of inertia and subjected to live loads. The first step is to calculate the fixed-end bending moments M_{Bf}, M_{Cf}, etc., for each support of each span, the coefficients

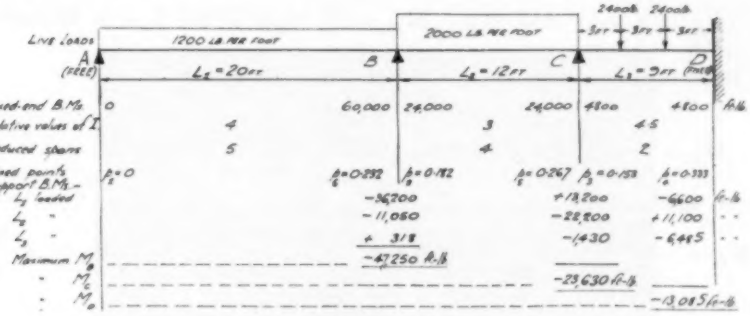


Fig. 1.

for which are given in many books. The second step is to calculate the " reduced spans " L′ which equal $\frac{L}{I}$, where I is the moment of inertia of the beam in span L. The position of the fixed point in either span L_n of two consecutive spans L_{n-1} and L_n is then calculated from

$$p_n = \frac{k(1 - p_{n-1})}{2 + 3k - 3p_{n-1}(1 + k)} \quad . \quad . \quad . \quad . \quad (1)$$

in which k is $\frac{L'_n}{L'_{n-1}}$ and $p_{n-1}L_{n-1}$ is the position of the fixed point in span L_{n-1}. Values of p and k can be tabulated for any degree of fixity.

At a free end, $p = 0$. Therefore in span L_1 (*Fig.* 1) $p_1 = 0$; in span L_2, $p_2 = \frac{k}{2 + 3k}$ from the left-hand support. Substitution in (1) gives p_3. Numerical values of p_2 and p_3 are given in *Fig.* 1. At a fixed end, $p = \frac{1}{3}$. Starting from the right-hand support in *Fig.* 1, $p_4 = 0{\cdot}3\dot{3}$, $p_5 = \frac{2k}{3 + 6k}$, and p_6 is calculated from (1).

The fixed points and fixed-end bending moments being known, the bending moments at the supports can be calculated from the following general formulæ

relating to any span B–C which alone is loaded and in which p_l relates to the left-hand fixed point and p_r to the right-hand fixed point.

If M_{Bf} is not equal to M_{Cf} (that is the load is unsymmetrical),

$$M_B = [M_{Bf} + (M_{Bf} + M_{Cf})(1 - 3p_r)]\frac{p_l}{1 - (p_l + p_r)}$$

$$M_C = [M_{Cf} + (M_{Bf} + M_{Cf})(1 - 3p_l)]\frac{p_r}{1 - (p_l + p_r)}.$$

If $p_l = p_r = p$,

$$M_B = \left[M_{Bf} + M_{Cf} + \frac{M_{Bf} - (M_{Bf} + M_{Cf})p}{1 - 2p}\right]p$$

$$M_C = \left[M_{Bf} + M_{Cf} + \frac{M_{Cf} - (M_{Bf} + M_{Cf})p}{1 - 2p}\right]p.$$

If $p_l = p_r = p$, and $M_{Bf} = M_{Cf} = M_f$ (that is the load is symmetrical), $M_B = M_C = 3M_f p$.

Applying the foregoing to the example in *Fig.* 1,

Due to the load on L_1:

$$M_B = -\frac{2p_6}{1 - p_6}M_{Bf};\quad M_C = +\frac{p_5}{1 - p_5}M_B;\quad M_D = -\frac{M_C}{2}.$$

Due to the load on L_2:

$$M_B = -\frac{3p_2(1 - 2p_5)}{1 - (p_2 + p_5)}M;\quad M_C = -\frac{3p_5(1 - 2p_2)}{1 - (p_2 + p_5)}M_f;\quad M_D = +\frac{M_C}{2}.$$

Due to the load on L_3:

$$M_C = -\frac{p_3}{1 - (p_3 + p_4)}M_f;\ M_D = -\frac{1 - 2p_3}{1 - (p_3 + p_4)}M_f;\ M_B + \frac{p_2}{1 - p_2}M_C.$$

The bending moments at the supports for each span loaded separately are given in *Fig.* 1, and the self-evident summations enable the maximum negative bending moment to be calculated.

The Cement Industry in Great Britain.

To mark the fiftieth year since its formation, the Associated Portland Cement Manufacturers, Ltd., has issued a brochure on the history of the company during the period. Many interesting facts are mentioned. For example, it is stated that the Associated group of companies is now the largest cement making and distributing organisation in the world. Using 100 to represent the price of cement in the year 1933, the price now is 170 compared with 360 for other commodities. The output of cement per man-hour is now 9·1 cwt., compared with 2 cwt. in the year 1910 and 7·3 cwt. in the year 1935. The deliveries of cement made from the group's factories in Great Britain were 6¼ million tons in 1949 compared with 5½ million tons in 1939 and about one million tons in 1900. It is shown that whereas in 1938 the home trade in cement was responsible for 66 per cent. of the profits of the group, this had fallen to 19 per cent. in 1949, when the export trade was responsible for 39 per cent. of the profits. In the year 1949 more than 1,300,000 tons of cement, valued at about £10,000,000, were exported by the group. In 1938 taxation accounted for 26 per cent. of the profits; in 1949 it had risen to 49 per cent. Fifty years ago there were no rotary cement kilns in use in Great Britain. The brochure gives some interesting photographs of cement manufacture fifty years ago, and also of some of the plant used to-day. Copies will be sent free on request to the company at Portland House, Tothill Street, London, S.W.1.

Impact Tests on Prestressed Concrete Fender Piles.

In a paper entitled "The Application of Prestressed Concrete to Structural and Building Work in the Gas Industry," published by the Institution of Gas Engineers, Mr. S. V. Gardner, reinforced concrete design engineer of the North Thames Gas Board, describes among other matters tests made on experimental prestressed concrete fender-piles similar to those used on a wharf at the Brentford works of the Board. The tests were made preparatory to the installation of extensive fendering (*Fig.* 1) to protect a river-side reinforced concrete road gantry, which is used for unloading coal, loading tar, and mooring barges. The barges using the berths do not at present exceed 350 tons displacement, and have a loaded draught of 9 ft. 3 in.; they arrive in groups and approach the berths from various directions, and also use the fenders as moorings. Each fender is a group of three piles, with another pile between each group. The following is from Mr. Gardner's paper.

An impact test was made on three pre-

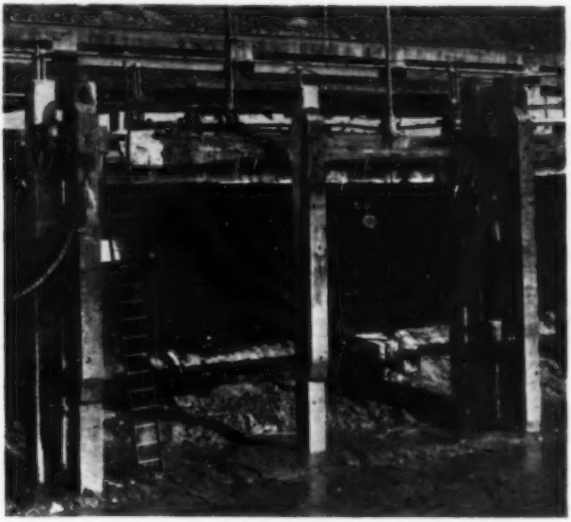


Fig. 1.—Prestressed Concrete Fender Piles at Brentford.

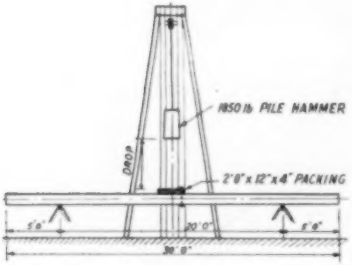


Fig. 2.

stressed concrete fender-piles 12 in. square and 30 ft. long. The piles are designed to provide a maximum moment of resistance of 200,000 in.-lb. The mixture of the concrete was 1 : 1½ : 3 by volume. The piles were about twelve weeks old when tested, at which age the estimated crushing strength of concrete cubes was 9000 lb. per square inch. Each test pile was supported symmetrically and horizontally on two rigid knife-edge supports 20 ft. apart (*Fig.* 2), and was subjected to the blows of a 1850-lb. weight falling distances increasing by 3 in. from 6 in.

to 60 in. A short length of 12-in. by 4-in. timber was bolted to the pile to receive the blows.

A record of the damped oscillations (*Fig.* 3) and the static and dynamic deflections measured at each impact was made. When a ship makes contact with an elastic fender, the ship and fender move a short distance before coming to rest, but in the tests the load generally remained on the beam after the initial impact and damped subsequent oscillations. With the larger falls the weight was found to rebound and create secondary impacts. The usual method of analysing the effect of impact is to assume that a heavy weight falls on a beam and the kinetic energy of the weight is equated to the resilience of the beam. From this basic equality an "equivalent static" load or "dynamic factor" is derived, and the effect of the impact is considered to

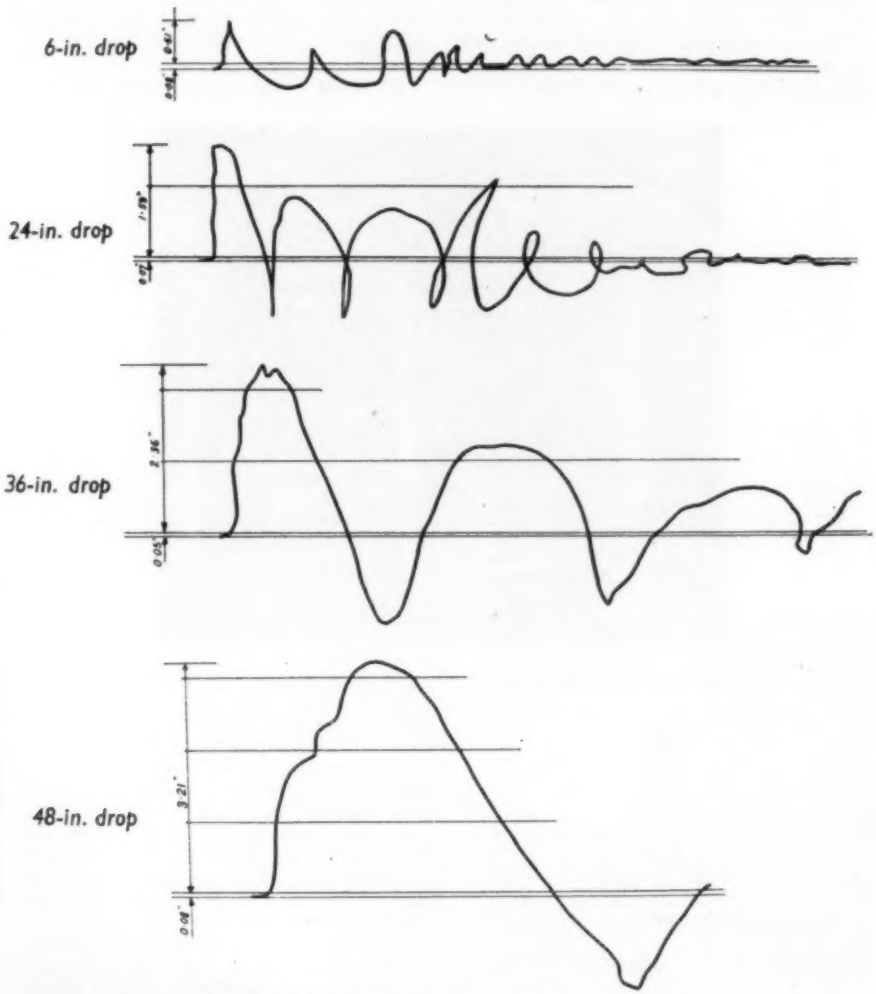


Fig. 3.—Oscillographs of Impact Test of Piles.

be similar to that of a static load multiplied by the "dynamic factor" to give the equivalent static load. If h is the distance the weight W falls, and d is the deflection at the middle of the beam due to the application of the static load, the dynamic factor q is given by the formula

$$q = 1 + \sqrt{1 + \frac{2h}{d\left(1 + 0{\cdot}485\frac{w}{W}\right)}},$$

in which w is the weight of the beam. Although the weight of a vertical fender does not influence the deflection in the same way as does the weight of a horizontal beam, this formula was used in analysing and comparing the results of the tests since the fenders were tested in a horizontal position. The application of more exact theories, such as those taking into account the variations of the resistance of the beam with the deflection and the mutual compressibility of the bodies on impact, was not considered to be justified or to contribute usefully to a problem in which so many unknown factors exist.

One pile broke when the weight fell 60 in. and the maximum deflection at failure was about 5 in., but for falls of 12 in. and 30 in. the deflections were 1 in. and 2 in. respectively. The values of "$q \times$ static load" calculated from the formula agreed very closely with the value of

$$\frac{\text{dynamic deflection}}{\text{static deflection}} \times \text{static load}$$

calculated from the observations made during the tests when the weight fell distances up to about 36 in., but with greater drops the divergence was considerable especially as failure approached.

Mr. Gardner has contributed the following additional notes:

The main purpose of considering prestressed concrete fenders was to save the large amount of timber required for a structure requiring extensive fendering. In the experimental stage it cannot be stated to what extent there is a saving in cost compared with timber. The great resilience of prestressed concrete renders it a suitable material for fenders provided that it is not subjected to localised impact. The results of the test on the 12-in. square prestressed concrete fender-piles show that this material can withstand large impact loads without disintegration. The tests were made on a limited scale because the immediate problem was to consider fendering for barges of moderate size. Further experimental work is contemplated before prestressed concrete fenders are used on a more extensive scale. The life of a prestressed concrete fender is not known, but those described have been in daily use for more than six months and show no defects. The piles and tests were made by the Concrete Development Co., Ltd.

A Code for Site Investigations.

CIVIL Engineering Code of Practice No. 1 (1950), entitled "Site Investigations," was recently published (price 10s.) by the Institution of Civil Engineers on behalf of the Civil Engineering Codes of Practice Joint Committee, and is the first of a series of six codes which will deal with foundations, drainage, and roads.

The code describes in twenty pages what to do when investigating the suitability of a site for a structure or other works, and how to do it is described in about one hundred pages of appendixes. About a fifth of the space allotted to appendixes is devoted to a concise and useful account of geology applied to engineering. Although some account is given of laboratory tests of soils, loading tests on the ground are described, and the manner of interpreting the results of such tests is explained. The ultimate bearing pressure is defined as the smallest pressure at which settlement continues without an increase in the load; or, on soils where this condition is not apparent, the pressure which causes a settlement equal to one-fifth of the width of the bearing area. The common recommendation that a study of the strata below a foundation should extend to a depth of 1½ times the width of an isolated foundation or of the structure is repeated. Other matters dealt with include descriptions and classifications of soils and surveys of sites.

A Prestressed Concrete Warehouse at Edinburgh.

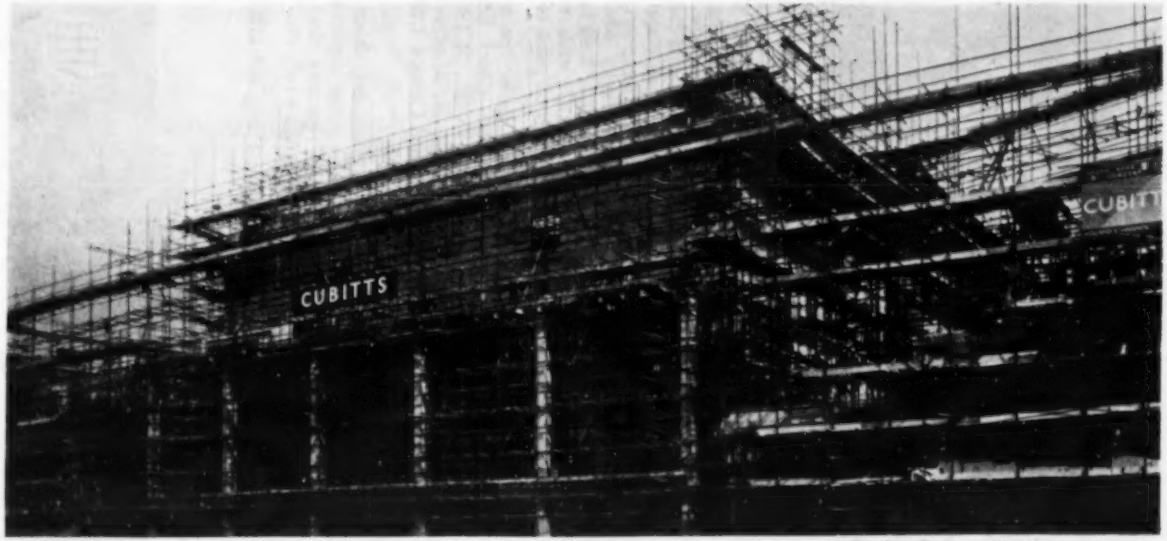
THE three-story warehouse for H.M. Stationery Office at Sighthill Industrial Estate, Edinburgh, the design and construction of which were described in this journal for November 1949, was completed last year. The floors, which are designed for a superimposed load of 3 cwt. per square foot, and roofs are of prestressed concrete; the columns and stairs are of ordinary reinforced concrete. The external walls (*Fig.* 1) are of concrete covered with $\frac{1}{8}$-in. sheets of anodised aluminium.

The building is largely of an experi-

Fig. 1.—Stationery Office Building, Edinburgh.

Fig. 2.—Precasting Prestressed Concrete Beams on Ground Floor.

STEEL FORMS



Architect of the London County Council:
Robert H. Matthew, A.R.I.B.A.

Consulting Engineers:
Messrs. Scott & Wilson, M.Inst.C.E.

Main Contractors:
Messrs. Holland & Hannen and Cubitts Ltd.

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This contract was carried out under the authority of the London County Council—Chief Engineer: J. Rawlinson, Esq., M.Eng., M.I.C.E., M.I.Mech.E., M.I.Mun.E. Architect: Robert H. Matthew, Esq., A.R.I.B.A.—by Messrs. Richard Costain Ltd., Civil Engineering Contractors.

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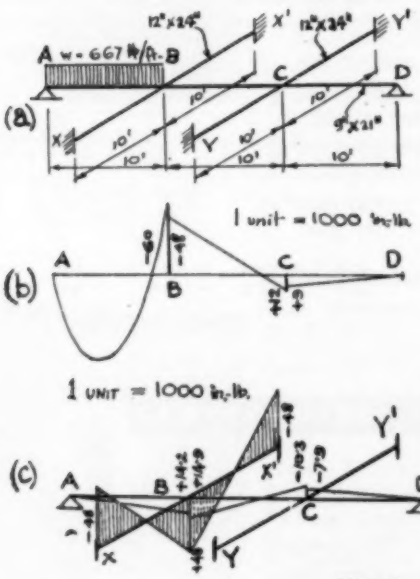
mental nature as at the time of its conception there was little experience of multiple-story prestressed concrete structures. In fact it is said that this warehouse, the prestressed concrete beams in which are constructed on Professor Magnel's system, is the first multiple-story prestressed concrete building in Europe. The Ministry of Works wished to erect such a building and this warehouse was chosen as being suitable because of the large number of identical beams. In addition, economy in the use of certain materials was essential, and prestressed concrete required the least quantities of steel, cement, and timber. The total weight of steel used, including the reinforcement in the foundations, is 210 tons. It has been calculated that a similar building with a steel frame would require 950 tons of mild steel, or 800 tons if high-tensile steel were used for the beams. At the time the work was commenced, there was little experience of the cost in this country of prestressed concrete compared with other methods of construction, and the contractors agreed to carry out the work at the same estimated cost as a building with a steel frame.

Fig. 2 shows the precasting on the ground floor of the secondary beams for the upper floors. In the background some of these beams are seen erected for the first floor. Construction commenced in February 1949, and H.M. Stationery Office took possession of the building in October 1950. The contractors were Messrs. Richard Costain, Ltd. [Crown copyright is reserved in the accompanying photographs.]

Torsion in Continuous Structures.

MR. S. J. MEDWADOWSKI writes: In the article on "Torsion in Continuous Structures" in your number for October, 1950, Mr. Chronowicz stated that the influence of the vertical deflection of the unsupported joints is ignored in the structures he investigated. The assumption that this influence on torsional and bending moments is negligible is true in the case of example No. 1 (page 364). In example No. 3 this influence is non-existent, due to the symmetry of the struc-



	I	S	S_T
BA	0·335	0·1	
BC	0·335	0·133	
X-Y	0·667		0·016

DISTRIBUTION FACTORS:
$\alpha_{BA} = 0{\cdot}38$ $\alpha_{BC} = 0{\cdot}51$
$\alpha_{BX} = 0{\cdot}11$

BA	X	BC	CB	Y	CD
0·38	0·11	0·51	0·81	0·11	0·38
-12·0		24·0	24·0		
-4·5		-6·1	-12·2		-3·0
		-6·1	-3·0		
2·3		3·1	+1·5		1·1
-14·2		14·9	10·3		-7·9

Fig. 1.

ture and the load. Consider, however, the unsymmetrically-loaded structure in example No. 2 of Mr. Chronowicz's article, which is shown in *Fig.* 1*a*. An exact analysis by the moment-distribution method is as follows.

Assuming that joints B and C rest on imaginary supports, the bending moments calculated in Mr. Chronowicz's article are given in *Fig.* 1*b* and in the top line of figures in *Table* I, which also gives the torsional moments. The calculated reactions at B and C are respectively $R_{BW} = + 4335$ lb. and $R_{CW} = - 575$ lb.

Now assume that joint B is displaced vertically an arbitrary distance such that the resulting fixed-end bending moments are $M_{BA} = - 12{,}000$ in.-lb., $M_{BC} = M_{CB} = 24{,}000$ in.-lb., and $M_{XB} = M_{BX} = - M_{BX'} = - M_{X'B} = - 48{,}000$ in.-lb. The distribution of these bending moments is given in *Fig.* 1*c*. Consequently the imaginary reactions at B and C are respectively $R_{BB} = - 1928$ lb. and $R_{CB} = + 276$ lb.

Now assume that joint C is displaced vertically by the same arbitrary amount as was B. Because of symmetry, the imaginary reactions at B and C are respectively $R_{BC} = + 276$ lb. and $R_{CC} = - 1928$ lb.

The following simultaneous equations express the condition that the sum of the reactions at the imaginary supports must be equal to zero:

$$- 1928x + 276y + 4335 = 0$$
$$+ 276x - 1928y - 575 = 0$$

from which the correction factors x and y are $x = + 2{\cdot}25$ and $y = + 0{\cdot}024$, which, when applied to the arbitrary bending moments due to the displacement of B and C separately, result in the bending and torsional moments given in the second and third lines of *Table* I. It is seen that, although the difference in the torsional moments is small, the bending moments differ considerably and some of them differ in sign—a factor of particular importance in the design of reinforced concrete structures. These differences would be even more pronounced in case of large grids and frames.

TABLE I.

	Bending moments (in.-lb. × 10^3)				Torsional moments (in.-lb. × 10^3)	
	M_{BA}	M_{BC}	M_{CB}	M_{CD}	T_{BX}	T_{CY}
Displacement of B and C neglected	− 60·0	− 48·0	+ 12·0	+ 9·0	− 6·0	+ 1·5
Due to displacement of B	+ 31·9	+ 33·5	− 23·2	− 17·8	− 0·8	− 2·7
Due to displacement of C	− 0·2	− 0·2	+ 0·4	+ 0·4	Approximately zero	
Summation	− 28·3	− 14·7	− 10·8	− 8·4	− 6·8	− 1·2

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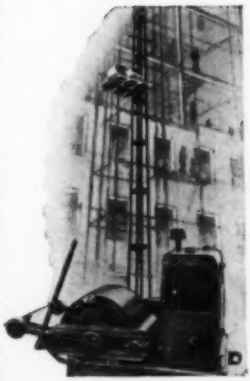

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5/10 cwt. 10/15 cwt. 20/30 cwt.

Wickham Winches can be supplied separately.

NOTE: *ALL WICKHAM HOISTS & WINCHES are already fitted with the requisite Safety devices to comply with the very latest Building Regulations 1948 No. 1145. Test certificate is supplied with each machine. S.G.B. Hire Plant is maintained in first class condition by highly skilled mechanics, thus ensuring trouble free running, whilst in operation.*

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Reconstruction of a Concrete Road in Leicestershire.

SIX HILLS road between Leicester and Nottingham was a lightly-metalled two-line road from 1923 to 1938 when 2¾ miles were reconstructed as a dual-carriageway concrete road. Work was suspended during the war, when the eastern carriageway was used as a military parking ground. This carriageway had so much deteriorated that in 1950 a new reinforced concrete surface was superimposed and the subsoil drainage, which had caused defects earlier, was improved. At the same time the western carriageway was surfaced with bituminous macadam and asphalt.

Fig. 1.—Lorry Containing Four Batches of Materials Discharging into Skip of Mixer.

The new reinforced concrete slab on the eastern carriageway, which was laid in two strips each 11 ft. wide with a plain butt joint between, is 6 in. thick and is reinforced with steel fabric 2 in. below the surface. In the part of the road reconstructed first, expansion and contraction joints are at intervals of 150 ft. with intermediate dummy-joints at intervals of 25 ft. In parts laid later, the dummy joints are omitted and the expansion and contraction joints are 100 ft. apart.

The proportions of the concrete were originally based on Table 5 in "The Design of Concrete Mixes" (published by H.M.S.O. for the Road Research Laboratory) to give a crushing strength of not less than 4000 lb. per square inch at 28 days, and the mixture was 1 part Portland cement, 2·4 parts fine aggregate, and 4·5 parts coarse aggregate, these proportions being by weight. The water-cement ratio was 0·5 and the compacting factor 0·8. This mixture, however, did not give uniform concrete and lacked sufficient workability to give a good surface, because of the presence of varying proportions up to about 20 per cent. of crushed particles in the coarse aggregate. Better results were given by a mixture comprising 1 part Portland cement, 2·6 parts fine aggregate, and 3·9 parts coarse aggregate, and a water-cement ratio of 0·55. The crushing

strengths of the concrete were 4320 lb. and 6050 lb. per square inch at 7 days and 28 days respectively.

The construction was mechanised as much as possible. The concrete materials were proportioned in ready-mixed batches at a plant about nine miles away and taken to the site in six tipping lorries each containing three or four batches. Each batch was tipped directly into the hopper of a 1-cu. yd. mixer (*Fig.* 1) travelling on an endless track. The concrete was discharged by a boom-and-bucket plant into a distributor which had on the underside doors to reduce the precompaction of the concrete. The distributor (*Fig.* 2) spread the concrete to a level 1½ in. higher than the side forms to allow for compaction. Two compacting machines were used, sometimes together and sometimes singly. The finished surface is as left after two passes of the machine (*Fig.* 3). A wet-surface profilometer was attached behind the compacting machines to record any unevenness in the surface after the passage of the compactor, so that remedial measures could be taken at once. The spreading and compacting machines travelled on rails on the stiffeners of the 6-in. steel forms, which were laid on a cement-mortar bed on the old concrete road and held in position by steel pins driven into holes drilled in the old concrete. Paper blankets, 50 ft. by 13 ft., were placed over the concrete as soon as practicable after the last pass of the compacting machine, and curing was continued for at least seven days.

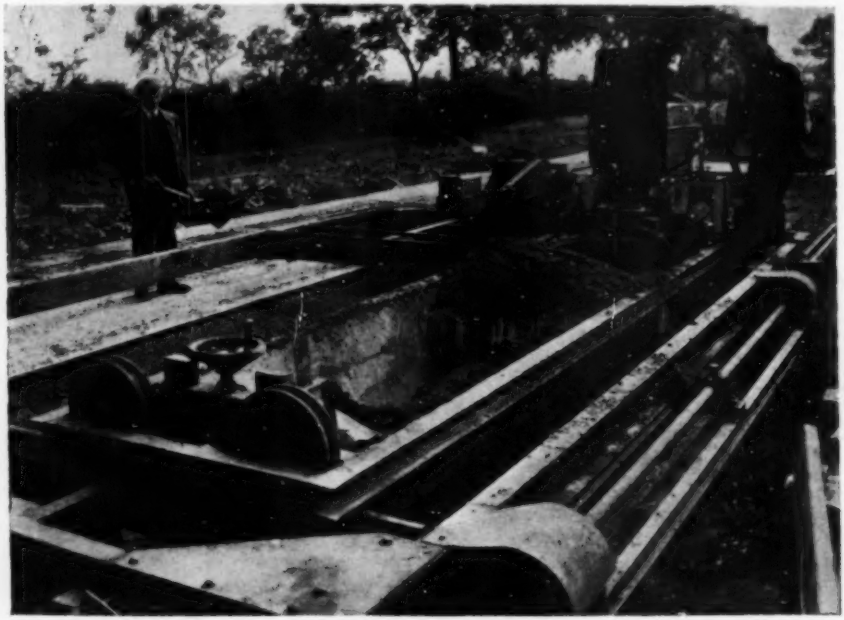

Fig. 2.—Spreading-machine.

The ¾-in. expansion and contraction joints were formed by a method developed by Mr. E. J. Powell, M.Inst.C.E., County Surveyor of Glamorgan. A U-shaped cap is fitted on the top of a premoulded joint filler and is locked in position by a steel bar passing through holes cut in the side-forms. The joint-filler is thus held vertically during the passage of the compacting machine, after which the steel bar is withdrawn, the arrises rounded, and the cap removed. Each joint is provided with ¾-in. dowel bars 24 in. long placed at 12 in. centres.

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SITUATION VACANT. Reinforced concrete designer-draughtsman required by consulting engineers. Post is not temporary. Salary will be based on qualifications and experience, and to assist this please give full details in your application. BOX 2448, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATION VACANT. Civil and structural engineer required by the Cement and Concrete Association, age about 35–40 years, with wide experience of reinforced concrete design and construction and ability to express technical ideas in a clear and concise manner. The work includes the interpretation of technical information on concrete construction, advising on the use of concrete, and translating the results of research work to practice. The post is progressive and pensionable. Commencing salary according to age and experience. Write, giving particulars, to 52 Grosvenor Gardens, London, S.W.1.

SITUATION VACANT. Reinforced concrete detailer required for permanent staff, Westminster. Salary £500–£700, according to experience. Applications, which should state age, details of experience, and salary required, to BOX 2449, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATIONS VACANT. Engineer-designer required in the Glasgow office of a well-known firm of reinforced concrete engineers. Considerable experience in reinforced concrete design is an essential qualification. Also required junior designers and draughtsmen-detailers with sound experience in reinforced concrete drawing office work. The posts offer long-term employment to suitable applicants. Superannuation and profit-sharing schemes are in operation. Write, giving full particulars and past experience, to BOX C.E. 590, at 191, Gresham House, London, E.C.2.

SITUATION VACANT. Senior engineer required for consulting engineer's office in London. Applicants should be Associate Members of either the Institution of Structural Engineers or the Institution of Civil Engineers. A good knowledge and experience of reinforced concrete and steelwork structures are required. The position entails the complete charge of contracts, including calculations, supervision of details, and site visits. Please apply in writing, stating age, qualifications, experience, and salary required. F. J. SAMUELY, 8 Hamilton Place, London, W.1.

SITUATION VACANT. The Railway Executive invite applications for post of designer in regional headquarters' office, London. Sound knowledge and experience of designing and detailing reinforced concrete structures required. Commencing salary £510, with increments of £30 and £35 at two-yearly intervals to £575 per annum. Applications should give full particulars and qualifications, experience and age, and should be sent within 14 days to CIVIL ENGINEER, THE RAILWAY EXECUTIVE, London Midland Region, Euston Grove, London, N.W.1.

SITUATION VACANT. Reinforced concrete designer required at branch office and depot, King's Lynn. Possibilities of a house. Apply J. L. KIER & CO., LTD., Setch, King's Lynn.

(Continued on page 97.)

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TRIANCO
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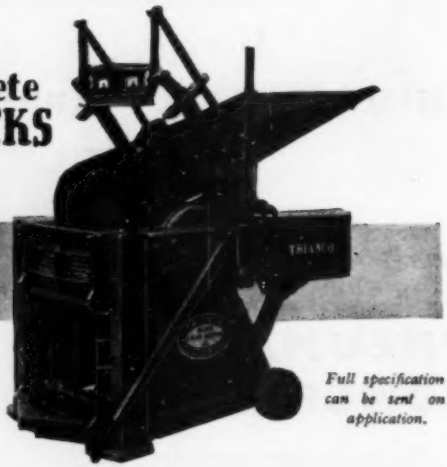

This machine is capable of making 100–125 blocks per hour. Designed for the production of partition slabs, but by means of additional fitments, hollow blocks, etc., can be made. It embodies the well-known TRIANCO double toggle mechanism for exerting simultaneous pressure at the top and bottom of the block or slab. Can be supplied with or without jolting attachment.

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Fig. 3.—Second Pass of Compacting Machine.

The average progress to date is about 340 ft. of 11-ft. road per day, the most in one day being 540 ft., that is 110 cu. yd. of concrete or 660 sq. yd. of road. The average total cost of the reinforced concrete slab to date is about 16s. per square yard, and is expected to be much less when the work is completed. The work is being carried out by direct labour by the Leicestershire County Council for the Ministry of Transport.

Research on mechanised road construction is being done on this site by the Committee of Co-operative Research of the Road Research Laboratory and the Cement and Concrete Association. Matters being investigated are the effective spreading of concrete to avoid variable compaction, compaction by different machines and the riding quality of the surface obtained by each, the setting of forms, and the movement or yield of the forms during the passage of the compacting plant. The riding quality is determined by a device which measures the total number of inches per mile which the surface is high or low. In the early stages of the work this measurement was 103 in. but has been reduced to 60 in., and further improvement is expected.

MISCELLANEOUS ADVERTISEMENTS
(*Continued from page* lviii).

MIDDLESEX COUNTY COUNCIL
COUNTY ARCHITECT'S DEPT.

ASSISTANT AREA STRUCTURAL ENGINEER, Apt. VI. Commencing salary £625 p.a. inclusive if 26 years or over. Established subject to medical report and prescribed conditions. Thorough knowledge of design and detailing of structures in either structural steel or reinforced concrete, and working knowledge of alternative methods of construction. Application forms from COUNTY ARCHITECT, 10 Great George St., Westminster, S.W.1 (stamped, addressed f'scap. envelope), to be returned by 24th March, quoting J.64CCE). Canvassing disqualifies.

C. W. RADCLIFFE
Clerk of the County Council.

SITUATION VACANT. Consulting engineers have vacancy for first-class designer-draughtsman, reinforced concrete. Write giving age, experience, and salary required. J. H. COOMBS & PARTNERS, Darby Gardens, Sunbury-on-Thames.

SITUATION VACANT. Designer-detailer required immediately by West Croydon firm of civil engineering contractors to prepare simple reinforced concrete schemes and working drawings. BOX 2452, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATION VACANT. Consulting engineers, Westminster, require civil engineer as salaried partner, age between 30 and 45, in Karachi, Pakistan. Salary £1,400 to £1,800 per annum according to experience, plus bonus guaranteed at £200 p.a. minimum. Applicants should have a public school education and possess the A.M.I.C.E. qualifications or equivalent University degree, and should be experienced in public works and reinforced concrete, structural steelwork, etc., either with Contractors or consulting engineers. Three months' leave with free passage home every two years. Applications giving full details of education and experience to BOX 2453, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATIONS VACANT. Several representatives required in England and Wales by manufacturer of precast concrete products, including passenger shelters and building units, etc. To sell, on a commission basis only, to public authorities, merchants, builders and civil engineers. Must already have connections with such organisations and be able to develop established contacts. Write stating (1) area covered, (2) lines already carried, (3) details of sales record, (4) experience and qualifications. BOX 2451, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

(*Continued on page* 98.)

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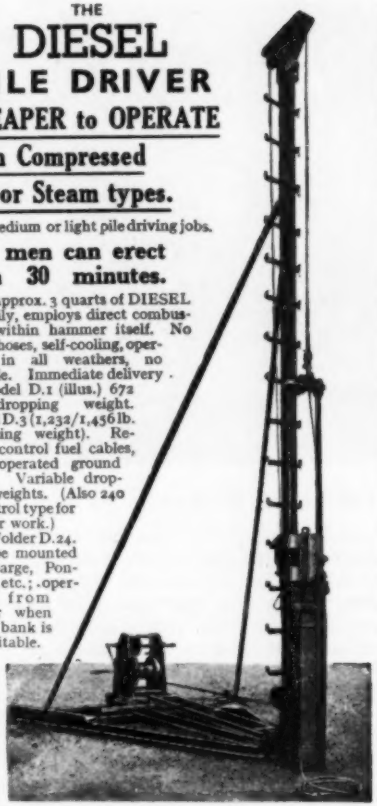

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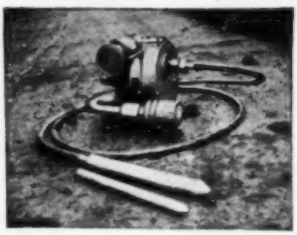

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MISCELLANEOUS ADVERTISEMENTS
(*Continued from page 97*).

SITUATION VACANT. Reinforced concrete draughtsman-detailer, with at least 3 years' experience, required in the first instance for service in the British West Indies. A suitable man would have an opportunity of joining the company's permanent staff. Write, stating age, experience, and salary required, to PERSONNEL MANAGER, HOLLAND & HANNEN AND CUBITTS, LTD., 1 Queen Anne's Gate, London, S.W.1.

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Apply at once by letter, stating age, full names in block letters, and full particulars of qualifications and experience, and mentioning this paper, to the CROWN AGENTS FOR THE COLONIES, 4 Millbank, London, S.W.1, quoting M.28420.D. on both letter and envelope. The Crown Agents cannot undertake to acknowledge all applications and will communicate only with applicants selected for further consideration.

SITUATIONS WANTED.

SITUATION WANTED. Reinforced concrete engineer, M.Sc. (London), A.M.I.C.E., A.M.I.Struct.E., also experienced in structural steelwork and civil engineering, seeks position in design and/or construction in this country, India, or Ceylon. Knowledge of Indian languages and conditions. BOX 2454, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

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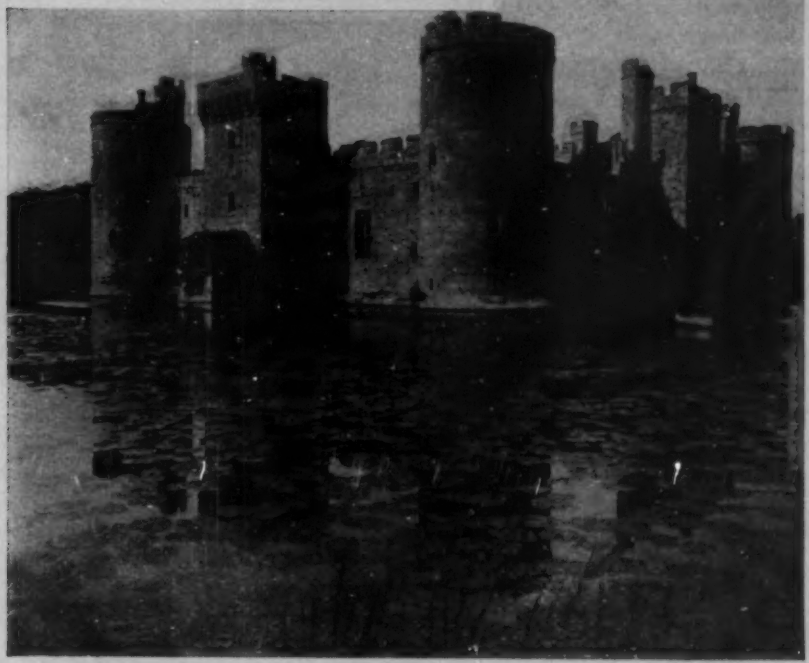

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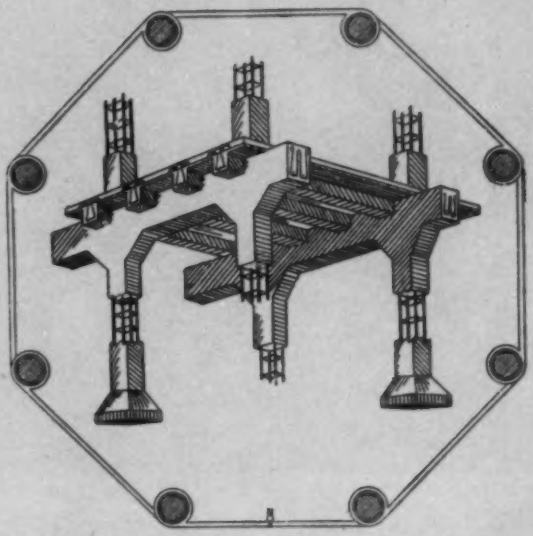

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